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ABSTRACT

This document provides the information needed to meet the standards for pesticide applicator certification. Section one deals with the identification of pests and the diagnosis of pest damage. Section two provides an introduction to weed characteristics and herbicide usage. The application, formulation, effects and safety of herbicides in general is discussed. Equipment use and handling are presented in section three. In particular this document discusses power sprayers and dusts and aerial equipment. Important practical calculation methods and conversions are provided and illustrated. A series of fact sheets on specific pests are provided in part four.
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COOPERATIVE EXTENSION SERVICE

University of New Hampshire

ORNAMENTAL, SHADE TREE, AND TURF

PEST CONTROL MANUAL

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
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PESTICIDE APPLICATOR TRAINING

This training manual is intended to provide you with the information you will need to meet the standards of the Environmental Protection Agency for pesticide applicator certification, and prepare you to take an examination given by the State Department of Agriculture based on this manual. It is not intended to provide you with all the information you need for effective ornamental and turf pest control. Additional information in the form of publications and short courses can be obtained from the Cooperative Extension Service.

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Section 1

I. Identification and Diagnosis

II. Types of Pests and the Ways They Injure Plants

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I. IDENTIFICATION AND DIAGNOSIS

Identification of the pest damage is the most important step in controlling the problem. Thorough knowledge of the crop and its growth characteristics is essential, otherwise evidence of the presence and damage of a pest may go undetected. It requires years of experience to be able to recognize the causes of poor plant growth and the signs of pest injury. This is one reason why diagnosticians prefer to work with a narrow range of commodities such as ornamentals, fruits, vegetables, field crops, etc. as we will here. Even then, there is no substitute for experience; the accurate diagnosis of plant ailments is a skill requiring much time and effort to develop. However, generalizations can be made that will help identify the cause of some ills of plants.

Some plant damage is caused by living pests, including disease agents, weeds, insects and mites, and vertebrate animals. Other causes of plant problems are non-living, such as too little, too much, or imbalanced fertilizer, pesticide injury, improper planting and pruning, root girdling, soil conditions (such as improper drainage, compaction), mechanical damage (by such things as earth-moving equipment, mowers, and hand tools), pollution damage, and natural aging of plants (often mistaken for damage caused by insects and diseases).

Careful observation often reveals the cause. For example, a canker disease may have girdled a twig or limb causing the leaves to wilt or die. However, to find the cause one must not only look at the leaf, but one must also look carefully along the twig or limb to find the cause. Or, an insect may be eating the roots of a plant -- the signs first appear on the leaves, but until the roots are examined, the cause cannot be correctly identified.

Two or more causes may produce the same symptom or sign of injury and there are hundreds of causes. With careful observation, knowledge of the plant's history, and a general knowledge of possible causes, plant ills can be frequently diagnosed without the need of a specialist.

Positive and correct identification of the problem is essential to effective control. Identification of pests is based primarily on observation of either the pest, its damage, or sign of damage, and then by process of elimination through knowledge of the host and its pests, the part injured, time of year, etc.

If you are unable to identify the pest or the damage from the information you have, you may wish to get an authority to come to the field to identify the

damage or pest. If this is not possible, you may wish to collect a sample to send him. No matter how much experience you have had, some problems will require further investigation and you will want to collect specimens. For more information on proper methods of collecting specimens for identification see the Appendix.

II. TYPES OF PESTS AND THE WAYS THEY INJURE PLANTS

Shade trees, ornamentals, and turf can be harmed by several different types of pests. Pests such as insects and mites, diseases, nematodes, weeds, and certain vertebrate animals will be discussed in the following pages.

INSECTS AND MITES

Ornamental plants are damaged by many kinds of insects and mites. Some suck sap from plants, others chew on or tunnel in plant parts or cause damage in other ways.

Some plants are very susceptible to insects and mites and require intensive pest control. Other plants are rarely attacked by insects or mites. Pest insect infestations vary from year to year, and control is not always needed.

Most insects injurious to plants have either a life cycle in which 1) the newly hatched insect differs from the fully grown adult primarily only in size -- the young or nymphs look like the adults in form except that the wings may not be developed and feed in the same places. Or 2) the adults and young are not alike -- the young or immature forms being worm-like larvae or caterpillars while the adults are moths, butterflies, flies, or beetles. (See illustrations on page 3.) In this, the damaging stage is often the larvae or worm stage at times when the adult cannot be found.

Often the insect found on the injured plant is not the cause of the injury to the plant, it just happened to be there.

Ways Insects Injure Plants

a. Chewing: devouring or notching leaves, eating wood, bark, roots, stems, fruit, seeds, mining in leaves. Symptoms: ragged leaves, holes in wood and bark or in fruit and seed, serpentine mines or blotches, wilted or dead plants, or presence of "worms."

b. Sucking: removing sap and cell contents and injection of toxins into plant. Symptom: usually off-color, misshapen foliage and fruit.

c. Vectors of diseases: carrying diseases from plant to plant. Examples: the elm bark beetle carries Dutch elm disease; various aphids carry virus diseases. Symptoms: wilt, dwarf, off-color foliage.

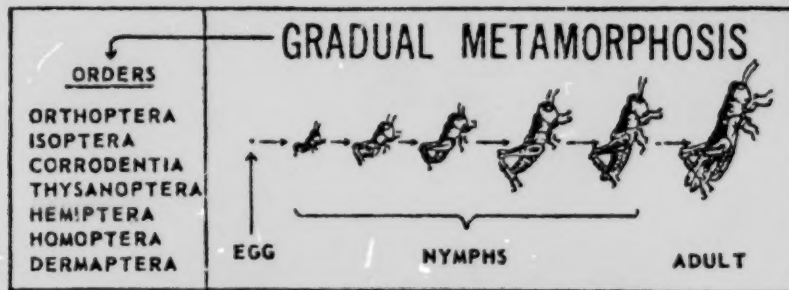
d. Alter the environment, and thus make it favorable for disease growth. Example: honeydew deposits lead to the growth of sooty mold and the leaves cannot perform their manufacturing functions which results in a weakened plant. Symptoms: sooty black leaves, twigs, branches, and fruit.

e. Gall formation: galls may form on leaves, twigs, buds, and roots. Symptoms: disfigure plants, and twig galls often cause serious injury.

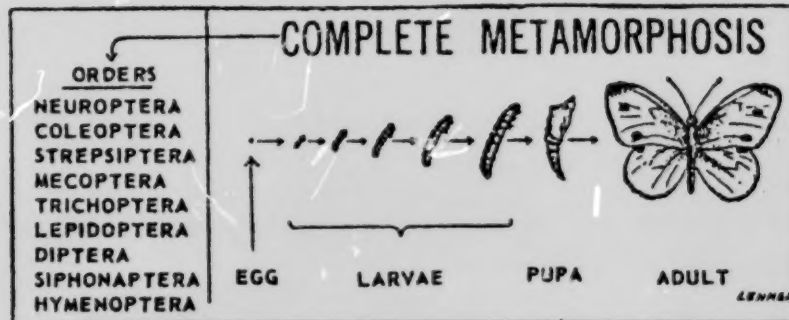
f. Oviposition scars: scars formed on stems, twigs, bark, or fruit.

g. Injection of toxic substances. Symptoms: scorch, hopper burn.

* Refer to Section 3 for more specific information on insects and mites which are pests to ornamentals and turf in New Hampshire.



Insects with gradual metamorphosis change shape gradually. Wings develop externally and as growth takes place, the nymphs look more like the adult.



In complete metamorphosis the insect goes through four stages of growth. None of the young looks like the adult. There is a great change in shape when the adult emerges from the pupal stage.

DISEASES

Unlike insects, you cannot always see the disease or its causal agent, but you can see the signs or symptoms of its presence or damage. Those that are not alive (non-infectious diseases) do not infect or live on the plant, but which cause damage are such things as air pollution, drought, etc. Those that are alive (infectious or parasitic diseases) are tiny organisms called pathogens. Disease signs such as mold, corn smut, or mildew can be easily recognized with the naked eye. However, in most instances you cannot see the organism causing the injury or damage without the use of a microscope. You see only the injury. Knowledge of the host plant, its diseases, and signs and symptoms are very important in identifying diseases in the field.

Disease Agents

Fungi, bacteria, viruses, nematodes, mycoplasmas, and parasitic plants cause diseases of landscape plants. Most common diseases are caused by fungi.

The environment is of major importance to the development of disease in woody plants. For example, a sudden drop in temperature in the fall or early winter increases the susceptibility of plants to cankers caused by fungi. Waterlogging of the soil contributes to the development of certain root rots. Prolonged periods of rain can cause an increase of such fungal diseases as scab and leaf spots.

Ways in Which Infectious or Parasitic Diseases Injure Plants

- a. Interfere with the supply lines by clogging water-conduction cells. Examples: late blight of tomato; strangulation by girdling cankers. Symptom: wilt.
- b. Destroy manufacturing equipment (chlorophyll). Examples and symptoms: blotch, scab, black spots on leaves.
- c. Destroy water- and mineral-collecting equipment. Examples and symptoms: blotch, scab, black spots on leaves.
- d. Gall-forming diseases disrupt the normal cellular organization. Symptom: unusual growths on flowers, twigs, and roots. Example: Crown Gall.

e. Cause flowers and seeds to rot. Examples: fireblight, bacterial rot of potato.

f. Produce toxins that kill plant tissues.

* Refer to Section 3 for more specific information on diseases which are pests to ornamentals and turf in New Hampshire.

NEMATODES

Nematodes are small animals, not plants. Most of those we are concerned about live in the soil and are round, thread or eel-like worms so small that they can hardly be seen. Some cause no harm, but others feed on or in the roots or stems of plants. A few feed on the leaves, stems, or seed, but are not a common problem. Young nematodes look like the adult except for their smaller size. Diagnosis is much easier when a crop is in the young or intermediate stages of growth. Symptoms are usually spotty and except for the galls of root knot, are not destructive enough for definite diagnosis. The nematode involved must be isolated and identified and the numbers must be estimated before the symptoms can be evaluated accurately. An examination of plant roots and soil taken from around the roots can help determine whether nematodes are wholly or partially responsible for poor plant growth.

Ways in Which Nematodes Injure Plants

a. Mechanically disrupt water conductive tissues or induce cell abnormalities resulting in inefficient translocation of water and nutrients. Symptoms: wilt, loss of color, yellowing of leaves; roots with necrotic spots or dead root tips and/or stunted roots, or loss of feeder roots.

b. Destroy water and mineral collecting equipment. Symptoms: stunted growth, poor vigor; roots with necrotic spots or dead root tips and/or stunted roots, or loss of feeder roots.

c. Gall formations on plant roots. Symptoms: root galls -- be careful not to confuse with nitrogen fixing nodules on legumes; bacterial or fungal infections.

* Refer to Section 3 for more specific information on nematodes which are pests to ornamentals and turf in New Hampshire.

WEEDS

Many kinds of weeds are pests in landscape plantings. Annual weeds are most troublesome in intensively cultivated ornamentals. Common annual weeds in ornamentals include grasses (crabgrass, foxtails, fall panicum, and barnyardgrass which germinate during the spring and summer, annual bluegrass and annual brome grass, which germinate during the late summer or fall, annual broadleafed weeds (purslane, pigweed, and lambsquarter) which germinate during the warm season and are killed by hard frost, and those that survive freezing temperatures (horseweed, common chickweed, bittercress, and pepperweed).

Biennial and perennial weeds are most troublesome in uncultivated ornamentals. They have underground plant parts that survive from year to year. They are spread in several ways. Many spread easily when carried in soil, in root balls, and on cultivating equipment, as well as by seeds. These include bermudagrass, Johnson grass, quackgrass, nutsedge, mugwort, and wild garlic. Seeds of perennial weeds such as dandelion and goldenrod are spread primarily by wind and water. Horsetail rush is spread by underground plant parts and by spores.

Ways in Which Weeds Injure Plants or Crops

- a. Reduced yields: competition for moisture, light, nutrients.
- b. Reduced crop quality: weed seeds, dockage, weeds in hay, straw, etc.
- c. Increased production costs: tillage, cultivation, harvesting, etc.
- d. Increased labor and equipment costs: seed cleaning, machinery wear and tear, etc.
- e. Lower land values.
- f. Insect and disease carriers or hosts: wheat stem rust, corn borer.
- g. Poisonous or irritating to animals or people: cocklebur seedlings, poison ivy, hay fever, etc.

* Refer to Section 3 for more specific information on weeds which are pests to ornamentals and turf in New Hampshire.

VERTEBRATE PESTS

Vertebrate animals may damage ornamentals in several ways. Some, such as mice, feed on roots and crowns. Others (including rabbits, deer, sap suckers, grossbeaks, and woodpeckers) feed on stems, trunks, twigs, or foliage. Moles feed on soil insects and cause damage by their tunneling.

Barriers, trapping, repellents, and pesticides all help control vertebrate pests. Control of the insects on which vertebrate pests feed is essential.

PESTS OF TURFGRASS

Pest control in turfgrass includes good cultural practices and chemical pest control. Turfgrass problems often result from causes other than pests. These other causes include improper watering, improper fertilization, injury from pesticides, accumulation of excessive thatch, improper selection of turfgrass species, improper mowing height, poor root systems, soil that is either too acid or too alkaline, or an accumulation of soluble salts in the soil. Be sure to consider these factors when diagnosing and treating turfgrass problems.

* Refer to Section 3 for more specific information on turf pests in New Hampshire.

APPENDIX

COLLECTING SPECIMENS FOR IDENTIFICATION

Plant Specimens for Insect, Disease, and Weed Identification

Above ground symptoms of insect and disease injury often result from injury to the root or vascular system. Therefore, it is best to take the whole plant for diagnosis. If possible, these plants should arrive for further study as close as possible to the time taken from the field. If various stages of damage or development of injury are present in the field, plants showing these different stages should be included.

Lift several plants out of the field by loosening the soil around the roots. Do not pull up the plant. Wrap cut stems or roots (without soil) in dry or slightly moist paper towel (not leaves). Pack the plant in crumpled paper or packing material to prevent crushing. The container should not be air tight. Plastic bags should have holes punched in them. Pack fruit carefully to prevent bruising.

A letter should accompany the sample giving the following information about the problem.

1. The name and variety of the plant, if known.
2. Symptoms seen on the plant while it was in the field. When did these symptoms first appear? Did they appear suddenly?
3. The field pattern of the problem. Does it spread along the rows? Is it only in a low or high area of the field? Is it in several places or only near the edge of the field?
4. Number of plants with the problem. A few plants or a quarter of the field? How severe is the problem?
5. Cultural practices. How was the field fitted out? What pesticides have been used? What type of irrigation has been used? What crops have been grown in the field previously?

The person making the diagnosis needs as much information as possible. Only then can he make the best diagnosis possible. Control methods can be recommended after the cause of the problem is determined. It is useless to waste time and money trying to control a disease or other pest when the cause of the problem is not known.

Insect Specimens

If possible, try to collect at least ten insects. Single insects are often difficult to identify and shipping damage is great.

Soft-bodied insects such as aphids, grubs, or caterpillars must be preserved in glass or plastic vials containing alcohol and then securely wrapped to avoid breakage in the mail. If possible, kill grubs or caterpillars in boiling water, then in alcohol. Indicate the original color of the specimen.

Hard-bodied insects such as beetles, wasps, flies, bees, and butterflies should be packaged in layers of cotton or facial tissue and placed in a pill box or other small container.

Ship in a box, tube, or any common shipping container acceptable to the postal department. IT IS UNLAWFUL TO SHIP LIVING INSECTS.

Include collection information as for plants.

Soil and Root Samples for Nematode Identification

A careful job of sampling can save much time and money. Soil and root samples should be taken from nearby plants which show symptoms of damage but which are not severely injured. Feeder roots (small rootlets) from approximately ten plants should be placed in a plastic bag with the soil. Small amounts of soil at a depth of 2-8 inches should be taken. If possible, take at least ten samples from the area showing injury. After sampling several spots representative of the area, mix the samples thoroughly in a bucket and take a composite sample of the resulting mixture. A one pint soil sample is generally adequate. If the field is fallow, take samples from the areas of poor growth and if immediately after harvest, they should be obtained from the plant row. Collect several samples at a depth of 8-10 inches deep and combine into a one pint composite sample.

A one inch diameter core sampling tube is preferred, but a trowel or large spoon will do.

Seal the bags tightly to prevent drying of the soil. Label the bags. Keep the samples out of the sun or a closed car on a sunny warm day. An ice chest is a convenient way to carry them. Heat kills nematodes. Samples can be held in a refrigerator up to a month at about 40°F. DO NOT FREEZE!!! Personal delivery is preferable to US Mail.

Section 2

**Introduction to
Weeds and Herbicides**

INTRODUCTION TO
WEEDS AND HERBICIDES

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A weed is a plant out of place, one which interferes with man's utilization of land. Weeds may occur as native or as introduced flora; 60 percent are introduced. Ten commonly accepted characteristics of weeds, in order of importance are:

<u>Characteristic</u>	<u>Additional Comments</u>
Indiscriminate, grows where not desired	Large; able to thrive anywhere
Competitive, aggressive	Reproduces many ways; establishes quickly; grows under poor conditions
Wild, rank	Large; grows quickly over wide area; is nitrogen-loving
Persistent, resistant,	Reproduces many ways; is protected from herbicides by form, biochemical tolerance, seed dormancy, or perennial nature.
Abundant	Adapts to crowding; has high seed numbers; is near mother plant
Useless and undesirable	Has no forage value, except perhaps as ground cover
Harmful to man, animals, crops	Has thorns or fibers; is poisonous, parasitic, or toxic
Spontaneous, not sown	Buried seed or parts are small and dormant; is sensitive and adaptable to tillage, crop cycles, and high fertility
Highly reproductive	Special structures aid dispersal; seeds are dormant
Unightly	Is dominant, aggressive, unattractive in flowers or foliage; replaces desirable forms

NAMING WEEDS

All plants have a true, or scientific, name and a common name. The first word of the scientific name refers to genus; the second word to species. For example, Cyperus esculentus is the true name for yellow nutsedge.

Common names for any plant may differ from place to place. For example,

Agropyron repens is called quackgrass by the Weed Science Society of America, wiregrass in Pennsylvania, and couchgrass in Canada and England.

Discussing weeds is easiest if common names are used, but efforts to standardize common names are only partially successful. Botanical names are awkward for general use, but are used in weed control literature to avoid confusion.

HOW WEEDS CAUSE LOSSES

Weeds cost Pennsylvanians at least \$127 million each year: more than \$100 million in field and forage crops; \$15 million in horticultural crops; and more than \$12 million in noncropland areas.

Weeds can host nematodes, or fungus and virus diseases; they can cause allergic reactions; they can taint food; and some can cause physical disorders or death. They also compete with crops, and interfere with planting, harvesting, and machinery efficiency. Some simply do not look good in a landscape.

SPREAD AND GROWTH OF WEEDS

DISPERSAL

Weed seeds are dispersed by natural forces and by animals or humans.

Natural forces include wind and water. Some weed seeds are small enough to be carried by water, and others, such as dandelion, are adapted to be moved by wind currents. In water, many seeds can float without damage.

Animals may carry seeds on barbs which attach to their hide or hair: beggarsticks and cocklebur are spread this way. Domestic animals may pass seeds through the digestive tract, infesting fields with weeds. If Johnsongrass appears near to feed lots, it will probably spread to fields. Birds spread weeds when intact seeds are passed through the digestive tract; mulberry and bitter nightshade are commonly spread by birds.

Man moves weed seed from one location to another in agricultural products, on machinery and clothing--in anything he handles. With equipment, he may drag tubers of nutsedge or rhizomes of quackgrass from one spot to another in fields.

DORMANCY

Seed dormancy is a survival mechanism for weeds. The three categories of seed dormancy are innate, induced, and enforced. The primary factors which affect dormancy are light, temperature, moisture, oxygen, afterripening, developmental stage of embryo, and condition and composition of seed coat.

INNATE DORMANCY

Innate dormancy means that after the seed leaves the parent plant, it requires some afterripening treatment, further development of immature embryos, leaching of natural inhibitors, or exposure to temperature extremes before germination can occur.

Seeds of different weed species vary in reaction to temperature. Crops are generally planted at or near optimum soil temperature for quick germination, but that may also be an ideal temperature for weed seeds.

Many seeds have a temporary dormancy which is broken by either low or high temperatures, preventing germination in the same season the seeds are produced and allowing the seeds to survive adverse weather conditions.

Water is required for germination. In dry soils, seeds may remain dormant until all other factors involved in promotion of germination reach at least a minimum level.

Seed coats may be waterproof, as are the coffeeweed seeds with their hard wax-like material over a dense covering around the embryo. Other hardseeds are morningglory, lespedeza, clover, and vetch.

Crop competition (shading) may intercept light rays and reduce weed seed germination when crops are in advanced stages of maturity.

The availability of oxygen is another factor which affects germination. Seeds may begin to germinate without air (anaerobic) and then shift to aerobic conditions when the seed coats rupture. Water may fill soil pores and exclude air, interfering with germination. Soil compaction may reduce the oxygen supply. Not cultivating at layby time keeps oxygen down, lowering the chances of germination.

INDUCED DORMANCY

Induced dormancy develops when a seed is exposed to specific environmental conditions, such as high soil temperatures, and becomes dormant. The dormancy lingers after conditions change. Yellow foxtail and smartweed react this way, and the seeds survive until the following spring when germination can occur.

ENFORCED DORMANCY

Enforced dormancy refers to environmental limitations which prevent germination. When the limitations are removed, seeds germinate freely. Plowing, deep tillage, or planting operations bring buried seed to the surface where they germinate readily. Special devices on turning plows bury weed seed at the bottom of the preceding furrow slice and enforce dormancy.

CONDITIONS AFFECTING WEED SEED GERMINATION

BURNING

Burning fields to destroy weed seed gives varying results, depending on heat intensity and duration. Many common weed seeds are destroyed when exposed to very high temperatures (175° to 212° F.) for 15 minutes. But if the burning creates only moderate heat, it may end dormancy of many seeds and induce increased germination because of greater temperature alternation, more light, less competition, and the removal of litter.

CUTTING

A common recommendation is to mow weeds to prevent seed production. The success of mowing depends upon proper timing.

Mowing when or before flower buds form prevents production of viable seed. But if flowers are open at mowing, much of the live seed falls back to the soil. Mowers often miss short-stemmed flowers which produce large numbers of seed.

STORAGE IN SILAGE

In storage, organic acids in silage kill many weed seeds within 10 to 20 days. However, some weed seeds may germinate after four years of silo storage.

SURVIVAL IN MANURE

Fresh manure spreads live weed seed, but well-rotted manure is generally free of living seed.

WEED REPRODUCTION

Weeds reproduce sexually or asexually. Sexual refers to those weeds that propagate by seed; asexual to those that reproduce by vegetative means such as runners, roots, or rhizomes.

HERBICIDES

Herbicides are chemicals used to kill plants or to interrupt normal plant growth. These chemicals can be classified in several ways: effect on plants; application time; application method; and similarity of chemical structure.

EFFECT ON PLANTS

Classification of herbicides by toxic effects is probably the most useful.

TRANSLOCATED HERBICIDES

Translocated (systemic) herbicides are absorbed by roots or leaves and distributed throughout the plant. The three groups of systemic herbicides are growth regulators, photosynthesis inhibitors, and cell-growth inhibitors.

GROWTH-REGULATING HERBICIDES

2,4-D	2,4-DEP (Falone)	MCPB
2,4,5-T	silvex	dicamba (Banvel D)
2,4-DB (Butoxone, Butyrac)	MCPA	picloram (Tordon)
		sesone

These herbicides cause responses similar to those of natural growth-regulating substances called auxins. Application of artificial auxins, such as 2,4-D, upsets normal growth as follows:

1. The cells of leaf veins rapidly divide and elongate, while cells between veins cease to divide. This results in a long, narrow, strap-like appearance of young leaves.
2. Water content increases, causing treated plants to be very brittle and easily broken.
3. Cell division and respiration rates increase; photosynthesis decreases. The food supply of treated plants is nearly exhausted at time of death.
4. Roots of treated plants lose their ability to take up soil nutrients, and stem tissues fail to move food effectively through the plant.

The killing action of the growth-regulating chemicals is not due to any single factor; plant death comes from the effect of several disturbances in the treated plant.

INJURY SYMPTOMS OF GROWTH-REGULATING HERBICIDES

On broadleaf plants, the leaves are crinkled, puckered, strap-shaped, stunted, and malformed; the leaf veins appear parallel, rather than netted; and stems are crooked and brittle, with shortened internodes.

On grasses (corn, for example), growth-regulating herbicides cause leaves to roll near the base in an onion-like fashion; the tip of the terminal leaf is free; and stems are brittle, curved or crooked, and have short internodes.

HERBICIDES INHIBITING PHOTOSYNTHESIS

In the presence of light, green plants produce sugar from carbon dioxide and water. Energy is required to rearrange carbon, hydrogen, and oxygen atoms to form sugar. For this necessary energy, electrons are borrowed from chlorophyll (the green material in leaves), and replaced by electrons split from water. If chlorophyll electrons are not replaced, the chlorophyll is destroyed and the plant's food manufacturing system breaks down.

The triazine, substituted urea, and uracil herbicides all block chlorophyll electron replacement. As preemergence treatments, these herbicides permit normal seed germination and seedling emergence, but cause the seedlings to lose their green color soon after emergence. The seedlings die after the food supply in the seed is gone. At low rates, these herbicides are more effective on seedling weeds than on established weeds.

Inhibitors of Photosynthesis:

Triazines: atrazine, simazine (Princep), prometryne (Caparol), propazine (Milogard), prometone (Pramitol), cyanazine (Bladex), cyprazine (Outfox)

Uracils: terbacil (Sinbar), bromacil (Hyvar X)

Substituted ureas: diuron (Karmex), fluometuron (Cotoran), norea (Herban), linuron (Lorox), chloroxuron (Tenoran), fenuron (Dybar), monuron (Telvar)

INJURY SYMPTOMS OF PHOTOSYNTHESIS-INHIBITING HERBICIDES

On broadleaf plants, early seedling growth appears normal, but shortly after emergence, leaves become mottled, then turn yellow to brown and die.

Grasses germinate and grow normally to the two- or three-leaf stage; then the leaves turn light green to white and the seedling dies.

HERBICIDES INHIBITING CELL GROWTH

Herbicides in this group cause abnormal cell development or prevent cell division. The carbamate herbicides prevent cell division in roots and shoots

while permitting other cell duplication processes to continue. This causes death of bud tissues and eventually plant death.

The nitroanilines also prevent cell division. They act primarily on developing roots.

Dalapon prevents cell division, but apparently kills plants by preventing the production of a vitamin. Dalapon acts primarily on shoot tissue.

INJURY SYMPTOMS OF CELL-GROWTH-INHIBITING HERBICIDES

Carbamates: chlorpropham (Chloro IPC) vernolate (Vernax)
EPTC (Eptam) butylate (Sutan)

On broadleaf plants, the leaves turn dark green, become wrinkled, and fail to unfold from the bud; the roots are shortened, thickened, brittle and club-like.

Young leaves of grasses fail to unfold, resulting in a crooked-neck, onion-like appearance; the tip of the terminal leaf is rigid and not free-flapping (flag-like); the roots are shortened, thickened, brittle, and club-like.

Nitroanilines: trifluralin (Treflan) benefin (Balan)
profluralin (Tolban) dinitramine (Cobex)
penoxalin (Prowl) butralin (Amex 820)

Seeds of treated broadleaf plants germinate but fail to emerge or emerge as severely stunted seedlings; seedlings have a thickened, shortened lower stem, small leaves and short, club-shaped roots.

Grass seeds germinate but generally fail to emerge; injured seedlings have short, club-shaped roots, and thickened, brittle stem tissue.

Dalapon: Dowpon

On broadleaf plants, the leaves are brown, with a burned appearance; stems may be twisted; and flowers, if present, are deformed.

Grasses treated with dalapon have leaves which become straw-colored several days after treatment; young leaves may fail to unfold, resulting in an onion-like appearance.

CONTACT HERBICIDES

Contact herbicides are non-selective and are sometimes called caustic herbicides; they appear to burn plant tissues. The burn results from cellular breakdown by:

- a. Direct injury to cell membranes: Phytotoxic herbicidal oils kill plants by dissolving parts of the cell wall.
- b. Protein coagulation: Dinoseb (Dinitro) and PCP cause coagulation of proteins, and rapid plant death.
- c. Inhibition of photosynthesis: Paraquat, diquat, linuron (Lorox) and prometryne (Caparol) oxidize chlorophyll and cause a buildup

of toxic materials which results in rapid death of treated tissues. The activity of these herbicides is delayed in the absence of light.

SOIL STERILANTS

Soil sterilants are a group of non-selective chemicals which keep the soil free of vegetation for one or more years. Many herbicides can be used as soil sterilants if applied at very high rates.

TIME AND METHOD OF APPLICATION

Herbicides can be broadly classified by time or method of application.

TIME

PREPLANT: Applied to the soil before crop planting. Example: butylate (Sutan) on corn.

PREEMERGENCE: Applied after crop is planted but before weeds emerge. Example: atrazine on corn.

POSTEMERGENCE: Applied after crop and weeds emerge. Example: dicamba (Banvel) on corn.

METHOD

BROADCAST: Applied over the entire field.

BAND: Applied to a narrow strip over crop drill row.

DIRECTED: Applied as a band directed toward the base of crop plant.

SPOT TREATMENT: Applied to small areas within a field.

STRUCTURE

Herbicides are often grouped together on the basis of similarity of chemical structure.

ORGANIC HERBICIDES

1. AROMATIC CARBOXYLIC ACIDS

Phenoxy herbicides:

2,4-D	
2,4,5-T	
2,4-DES	(Sesone)
2,4-DB	(Butyrac 200, Butoxone)
2,4-DEP	(Falone)
MCPA	(Methoxon)
MCPB	(Cantrol, Thistrol)

Benzoic acids:

dicamba	(Banvel D)
TIBA	
2,3,6-TBA	(Trysben, Benzac)
chloramben	(Amiben)

Phthalic acids:

naptalam	(Alanap)
DCPA	(Dacthal)

2. ALIPHATIC ACIDS

dalapon	(Dowpon)
TCA	(TCA)

Organic arsenical herbicides:

MSMA	(Ansar 170)
DSMA	(Ansar 184, Clout)
MAMA	(Ansar 157)
AMA	(Methar)
CMA	(Calar, Crab-E-Rad)
cacodylic acid	(Phytar, Erase)

3. HETEROCYCLIC NITROGEN DERIVATIVES

Ring substituted triazines:

ametryne	(Erik)
atrazine	
cyanazine	(Bladex)
cyprazine	(Outfox)
metribuzin	(Lexone, Sencor)
prometone	(Pramitol)
prometryne	(Caparol)
propazine	(Milogard)
simazine	(Princep)
procyazine	(Cycle)

Substituted uracils:

terbacil	(Sinbar)
bromacil	(Hyvar X)

Other heterocyclic nitrogen derivatives:

amitrole	(Amitrol)
picloram	(Tordon)
maleic hydrazide	(MH-30)

4. ALIPHATIC NITROGEN DERIVATIVES

Substituted ureas:

diuron	(Karmex)
noorea	(Herban)
fluometuron	(Cotoran)
linuron	(Lorox)
chlorbromuron	(Maloran)
chloroxuron	(Tenoran)
fenuron	(Dybar)
manuron	(Telvar)

Substituted amides:

diphenamid	(Enide, Dymid)
CDA	(Randox)
propachlor	(Ramrod)
alachlor	(Lasso)
propanil	(Stam)

Carbamates:

chloropropham	(Chloro IPC)
EPTC	(Eptam)
vernolate	(Vernam)
pebulate	(Tillam)
butylate	(Sutan)
prophram	(ICA Chem-Hoe)
barban	(Carbyne)
terbutol	(Azak)
CDEC	(Vegadex)
triallate	(Avadex BW)

5. NITROANILINES

trifluralin	(Treflan)
benefin	(Balan)
penoxalin	(P-owl)

6. SUBSTITUTED NITRILES

dichlobenil	(Casoron)
ioxynil	(Certol, Actril)
bromoxynil	(Brominal, Buctril)

7. SUBSTITUTED PHENOLS

dinoseb	(DNBP)
DNOC	(Sinox)
PCP	(Penta)

8. METAL ORGANIC HERBICIDES

sodium chlorate
calcium cyanamide (cyanamid)
sodium cyanate
potassium cyanate
phenyl mercuric acetate (PMA)
ammonium sulfamate (Anmmate)

INORGANIC HERBICIDES

Sodium borate; arsenic trioxide; sodium arsenite; copper sulfate.

HERBICIDE FORMULATIONS

Herbicides are sold not as pure chemicals but as a combination or formulation of one or more herbicides with various additives. Surfactants, emulsifiers, adhesives, or various diluents may change the activity of a pure herbicide to the advantage of the user. Toxicity to plants, uniformity of plant coverage, and stability in storage depend on formulation. However, the primary function of formulation is to permit uniformity and ease of application. Herbicides are formulated to be applied as sprays, granules, or dusts.

SPRAYS

SOLUTIONS are homogeneous mixtures of two or more substances. A solution may be either clear or colored and cannot be separated by mechanical means. An example of a solution is 2,4-D amine dissolved in water.

EMULSIONS are one liquid dispersed in another, such as 2,4-D esters dispersed in water. Emulsions appear milky when dispersed in water. Without agitation, the liquids may separate.

WETTABLE POWDERS are finely divided solid particles that may be dispersed or suspended in water. Suspensions of wettable powders appear cloudy. Wettable powders are nearly insoluble and require agitation to remain in suspension. Atrazine and linuron are formulated as wettable powders.

GRANULES

Herbicides in granular formulations are applied in a dry state with a carrier. The carrier may be clay, sand, vermiculite, or ground corn cobs. Performance of granulated herbicides, compared with sprayable formulations, varies with the herbicide. Granular forms generally require more rainfall for activation than do sprayable formulations.

Advantages:

Water is not needed for application.
Relatively inexpensive equipment can be used for application.
May be very selective because granular particles fall off leaves, and sift through a canopy to the ground.

Disadvantages:

Heavy, bulky, troublesome to store or ship.
Small granules are subject to drift.
Application is not as uniform as sprays.

DUSTS

Dusts are popular formulations of insecticides and fungicides. Because of drift hazard, few herbicides are applied as dusts.

HERBICIDE-LIQUID FERTILIZER COMBINATIONS

Herbicides may be combined with liquid fertilizers to minimize trips over the field. Information is scarce concerning compatibility of herbicides with specific fertilizer solutions. Herbicide-fertilizer solution combinations may form a jell that will not flow through sprayer equipment. Other combinations may form solids that settle to the bottom of the sprayer tanks. The compatibility of herbicide-fertilizer combinations should be tested prior to mixing the components for field applications. In some cases, addition of a surfactant (Compex, Buffer X, or comparable surfactants) may aid in maintaining component dispersion.

The following procedure may be used to test the compatibility of herbicides with liquid fertilizers:

1. Fill two one-quart jars with the fertilizer solution to be tested. Add one teaspoon of surfactant to one of the jars.
2. Add the necessary amount of herbicide (as specified by the chart below).

Gallons of Liquid
Fertilizer Per Acre*

Herbicide to be Added Per
Quart of Fertilizer Solution**

10	5.0 teaspoons
15	3.0 "
20	2.5 "
25	2.0 "
30	1.5 "
50	1.0 "
100	0.5 "

* Test the components at the temperature that will exist in the field at application time. Incompatibility problems are most serious at low temperatures.

** The amounts listed are equivalent to approximately one quart of liquid herbicide or two pounds of wettable powder herbicide as the commercial formulation per acre.

Observation:

1. If, after standing for ten minutes, the components in the jar with no surfactant are dispersed, the herbicide is compatible and no surfactant is needed.
 2. If the components are dispersed only in the jar containing surfactant, the herbicide is compatible only if a surfactant is added.
 3. Should the components not be dispersed in either jar, then the herbicide-fertilizer solution mixture is not compatible and should not be used.
- Should the herbicide-fertilizer mixture prove compatible in this test procedure, it may be applied as a mixture on a field basis, provided vigorous agitation is maintained in the spray tank.

HERBICIDE SAFETY

Recommended herbicides will not cause injury to humans, livestock, wildlife or crops if used properly and if recommended precautions are observed. However, any herbicide is potentially dangerous if improperly handled or used. Avoid splash or spray contact, and keep exposure to a minimum. Never keep herbicides in containers that are improperly labeled or easily accessible to children. Never dump unused herbicides where water supplies may be contaminated.

Most commonly available herbicides are given in the following table. They are listed in order of decreasing oral toxicity.

HIGHLY TOXIC HERBICIDES

(probable lethal dose for a 150-pound man
is a few drops to 1 teaspoon)

Sodium arsenite ^{1,2}
Dinoseb (DNBP, Dinitro) ¹

Endothall (Aquathol, Des-i-cate) ³

TOXIC HERBICIDES

(probable lethal dose for a 150-pound man
is 1 teaspoon to 1 ounce)

Arsenic
PCP (Sod. Salt) ¹
Copper Sulfate (bluestone)
Diquat

Paraquat
DMPA (Zytron) ⁴
2,4-D (acid) ⁴
2,4,5-T (acid and ester) ⁴

MODERATELY TOXIC HERBICIDES

(probable lethal dose for a 150-pound man
is 1 ounce to 1 pint or 1 pound)

DSMA (Ansar 184, Clout)
MCFA (acid)
2,4-DB (Est'd) ³
CDEC (Vegadex) ³
Calcium Cyanamide (Cyanamid)
Diphenamid (Dymid, Enide)
MCFA (amine)
Linuron (Lorox)
EPTC (Eptam)
Vernolate (Vernam)
Arsenic acid
Norea (Herban)
DCPA (Dacthal)
Dicryl (Chloranocryl)
Monuron (Telvar) ⁴
Chloroxuron (Tenoran)
Dalapon (Dowpon) ⁴
Simazine (Princep)
Amitrol-T (Cytrol)

2,4-D (Sod. Salt)
2,4-D (Isop. ester)
AMA (Methar)
2,4-DES (Sesone)
Dicamba (Banvel-D)
Pebulate (Tillam)
Cacodylic acid (Phytar, Erase)
AMS (Ammate)
NPA (Alanap)
Bensulide (Betasan)
Dichlobenil (Casoron)
Proetryne (Caparol)
Atrazine
Diuron (Karmex) ⁴
Chloramben (Amiben)
Prometryne (Caparol)
Propazine (Milogard)
Chlorpropham (CIPC)
Trifluralin (Treflan)

ALMOST NON-TOXIC HERBICIDES

(probable lethal dose for a 150-pound man
is more than 1 pint)

Bromacil (Hyvar X)
MH (Sod. Salt)
Picloram (Tordon)
Benefin (Balan)
Amitrole (Weedazol) ⁴

Sodium Borate ⁴
Fenuron (Dybar)
Fluometron (Cotolan)
Sodium Chlorate ⁴
Terbutol (Azak)

Dermal response: ¹ is absorbed and poisonous
² causes burns and blisters
³ is moderately irritating
⁴ is mildly irritating

LIVESTOCK SAFETY

Herbicides sprayed on plants are not generally toxic to livestock, but animals may be poisoned by eating unused herbicides left in open containers or by drinking water contaminated with herbicides.

Certain unpalatable or poisonous plants treated with herbicides may become palatable to livestock. Be certain that livestock cannot get to poisonous plants which have been sprayed with herbicides.

The nitrate content of several kinds of weeds may be increased after spraying with 2,4-D, Banvel, or similar herbicides. Cattle browsing on these treated plants may become ill. Remove all animals from sprayed areas for several days or until after rain or after death of the weeds.

Milking dairy cattle should be kept off pastures for seven days after spraying with 2,4-D-type herbicides.

SAFETY TO GAME AND FISH

Controlled spraying may be beneficial to wildlife by maintaining desirable cover. Herbicides recommended for control of aquatic weeds give beneficial results for fish populations. Be sure to apply these herbicides properly. Do not drain or flush equipment where chemicals may wash into ponds or streams, and do not leave open containers where curious animals might find them.

CROP SAFETY

Farmers are occasionally concerned about possible herbicide injury to crops. Most injury of this kind is caused by misuse, contaminated equipment, or drift. Unfavorable weather and herbicide residues from the previous crop are also often associated with herbicide effects on crops.

MISUSE

Improper sprayer calibration, non-uniform application, calculation errors, and use of the wrong chemicals can cause herbicide injury.

Only the recommended amount of herbicide should be applied. Slight increases in rate could result in crop injury or residues which would injure succeeding crops.

It is necessary to recalibrate sprayers frequently to adjust for increased output due to normal nozzle wear. Be sure there is sufficient agitation in the sprayer tank to prevent settling of wettable powders.

Do not stop sprayers in the field, spill tanks when loading, or dump unused herbicides where desirable plants are growing.

The following steps should be taken when mixing herbicides:

1. Calculate the amount of herbicide to add to the sprayer tank on the basis of the active material in each gallon of herbicidal concentrate or the percentage of active ingredient of wettable powder.
2. Read and follow the instructions on the manufacturer's label pertaining to personal hazards in handling.
3. Never pour concentrated herbicides into an empty tank.
 - *First fill the tank half-way with water.
 - *Operate sprayer by-pass to mix thoroughly and to maintain suspension by continuous agitation.
 - *Add the herbicidal concentrate.
 - *Finish filling the tank with water.
4. To ensure thorough mixing, operate the sprayer rig with the control valve closed for several minutes. This by-passes the liquid into the tank.
5. Never allow a sprayer containing mixed chemicals to stand without agitation. Heavy wettable powders may clog nozzles or settle into corners of the spray tank.
6. Always be sure the sprayer has been calibrated properly to ensure the application of recommended rates.

CONTAMINATED EQUIPMENT

Sprayers used to apply 2,4-D-type herbicides may be used to apply other chemicals before crops are planted or before crop plants emerge, but equipment must be thoroughly cleaned before applications are made to emerged crops (except grasses). Ester formulations are harder to remove than are amine or salt formulations.

To remove esters, flush out the entire system with a water-detergent solution immediately after spraying. Then fill the tank and prime the system with an ammonia solution of one gallon of household ammonia to 100 gallons of water, and leave it undisturbed for 12 to 24 hours. Take the nozzles apart and soak the caps, screens, bodies, etc., in ammonia solution. (Five pounds of Sal soda or eight pounds of trisodium phosphate can be substituted for ammonia). Rinse the system thoroughly with water and let it circulate through the sprayer.

For falone or sesone formulations, follow the recommended procedure for esters, but use five gallons of vinegar instead of one gallon of ammonia.

After using amine or salt formulations or liquid herbicides, clean the equipment by flushing out the entire system with a water-detergent solution, and rinsing with clean water.

Wettable powder residues must be removed immediately after use: Flush the entire system with clean water, then remove sprayer nozzles and clean residues from screens. Rinse the system with a detergent solution followed by clean water. Replace the nozzles. (The herbicide label may suggest special cleaning procedures.)

As a test for a residual herbicide, spray a few plants of a susceptible crop four to five days before using the sprayer on large areas.

DRIFT

The term "drift" is applied to movement of any pesticide through the air to areas not intended for treatment.

Particle drift: At the time of application, small spray droplets or dust particles are carried by air movement from the application area to other areas.

Vapor drift: After application, herbicides evaporate (volatilize) and yield fumes (gases) which are carried on wind currents and deposited on soils or plants in untreated areas.

Drift may injure sensitive crops, ornamentals, gardens, livestock, wildlife, or people, and may contaminate streams, lakes, or buildings. It may contaminate crops and cause illegal or intolerable residues. Excessive drift may mean poor performance in the desired spray area because the application rate is less than expected.

Highly active chemicals present the greatest drift hazard, since extremely small amounts of these chemicals can cause severe problems. For example, growth-regulating herbicides, such as 2,4-D, dicamba, and picloram, at a rate of one ounce per acre, can deform sensitive crops, such as tobacco or tomatoes.

Vapor drift problems can often be avoided by use of non-volatile formulations. Essentially, no vapor drift hazard is involved in the use of amine formulations of 2,4-D.

Particle drift depends on the size of the particle or droplet; and droplet size depends on pressure and nozzle design. Very small particles of fog or mist size present the greatest drift hazard. To minimize particle drift, equipment should be calibrated to create droplets about the size of light rain.

Most nozzles can be adjusted to a pressure which permits droplet formation as a result of surface tension. If nozzles are operated for this pressure, a minimum of mist-sized droplets will be formed. For some nozzles, this pressure may be as little as 10 pounds per square inch; for others, 30 pounds per square inch.

The distance that particles will drift increases with the height of release. Wind velocities are usually lower close to the ground. Therefore, sprays should be released as near the soil surface or vegetation as adequate coverage will permit.

Drift hazard is usually minimized if prevailing winds are blowing away from sensitive crops. However, a sudden shift in wind direction could result in serious damage. If possible, do not apply pesticides when the wind is strong.

High temperatures increase the loss of volatile herbicides. Esters of 2,4-D rapidly evaporate at temperatures above 80° F. The use of such ester formulations should be restricted to fall, winter, and early spring because sensitive plants are not present, and because low temperatures reduce vapor drift hazard.

Drift control should be considered in every pesticide application. Severe problems associated with drift can be avoided by:

1. Using low volatile or non-volatile formulations
2. Using low spray delivery pressures (20-40 pounds per square inch)
3. Applying at high volume
4. Avoiding application of volatile chemicals at high temperatures
5. Spraying when wind speed is low and blowing away from areas that should not be contaminated
6. Leaving border areas unsprayed if they are near sensitive crops

EVALUATIONS OF POSSIBLE HERBICIDE INJURY

Insects, diseases, severe weather (hail, drought, flooding), fertilizer burn, nutrient deficiencies, and many other factors produce symptoms that can be easily confused with herbicide injury. In evaluating crop injury, it is necessary to consider:

1. Are similar symptoms present in treated and untreated areas within the same field or in crops grown in or near the area in question?
2. What is the history of the problem field--the fertility program, cropping sequence, land preparation, and seed source?

Careful consideration of these points will aid in the diagnosis of the problem.

FACTORS AFFECTING HERBICIDE PERSISTENCE

The residual life or length of time that a herbicide persists in the soil is the length of time that weed control can be expected. Residual toxicity, if not taken into consideration when planting in an herbicide-treated field, may injure succeeding crops.

The inactivation, breakdown, and disappearance of herbicides is influenced by soil and environmental factors.

MICROBIAL BREAKDOWN

Microorganisms use all types of organic matter, including organic herbicides, as food supplies. Some herbicides are more readily attacked by microorganisms than others. This is often due to minor differences in chemical structure which permit rapid decomposition in one case and block decomposition in others. Soil temperature, aeration, pH levels, organic matter, and moisture levels favorable for microbial growth promote rapid herbicide breakdown.

LEACHING

Water carries herbicides out of the root zone. The amount lost to leaching depends on soil texture, herbicide solubility, and amount and intensity of rainfall. As a rule, herbicides leach most from sandy soils and least

from clay soils and soils containing a high percentage of organic matter.

ADSORPTION

After application, herbicides may become adsorbed (bound) to clay and organic matter particles. The extent of adsorption increases as the percentage of organic matter and/or clay increases. Adsorption reduces the amount of chemical available to plants, slows leaching, and retards microbial breakdown.

CHEMICAL BREAKDOWN

Herbicides may be activated by reaction with water, salts, acids, and other substances in the soil. These reactions are affected by the same environmental factors that affect microbial breakdown.

VOLATILIZATION

Some herbicides may be rapidly lost as fumes after application. Loss as vapor reduces the persistence of nitroaniline and carbamate herbicides and of dichlobenil. The rate of vapor loss is influenced by soil moisture, temperature, and adsorption.

The loss of herbicides in vapor increases as sand, soil moisture, and soil temperature increases. Incorporation immediately after application prevents this kind of loss.

PHOTODECOMPOSITION

Sunlight may inactivate herbicides. This may be an important factor contributing to activity loss of unincorporated trifluralin (Treflan), nitralin (Planavin), and benefin (Balan). Light exposure of two or more hours reduces the effectiveness of trifluralin and related herbicides, and can be avoided by soil incorporation.

PLANT UPTAKE

Herbicides may be absorbed by plant roots or leaves and be either accumulated or inactivated within the plant. Generally, herbicide removal by plants accounts for a relatively small amount of herbicide loss.

Section 3

- I. Power Sprayers, Power Dusters, and Aerial Equipment for Pesticide Application
- II. Sprayers and Pesticide Application Equipment for Turf
- III. Calculation Methods and Conversions for Pesticide Application

I. POWER SPRAYERS, POWER DUSTERS, AND AERIAL EQUIPMENT
FOR PESTICIDE APPLICATION

Power Sprayers.....page 1
Power Dusters.....page 9
Aerial Equipment.....page 11

POWER SPRAYERS

Four classes of power-spraying and dusting equipment are used on farms:

- Hydraulic sprayers
- Air sprayers
- Fog applicators or aerosol generators
- Dusters

Models of these are available in several types and sizes. Some units are designed for specific spraying or dusting operations, and some are general-purpose units.

HYDRAULIC SPRAYERS

Hydraulic sprayers discharge the spray by the direct action of a pressure pump on a liquid spray material. The pressure forces the liquid spray through nozzles, which break it into droplets of the proper size and disperse them in the desired spray pattern.

Hydraulic sprayer units can be purchased complete or can be assembled from component parts. Five general classes of hydraulic sprayers are commercially available:

- Small general-use sprayers
- Multiple-purpose farm sprayers
- High-pressure, high-volume sprayers
- Low-pressure, low-volume sprayers
- Self-propelled, high-clearance sprayers

COMPONENT PARTS

Different spray jobs call for different spraying pressures, different kinds and amounts of spray materials, and different methods of application. Therefore, in buying or assembling a sprayer, particular consideration must be given to the type and size of pump, the size of the tank, the method of agitating the spray material, the type of distribution system, and the nozzles.

PUMP

The pump (with other components) determines the spraying pressure and spraying capacity of the sprayer and the kinds of spray materials that can be handled. The types of pumps are compared in the chart on the following page.

The type and size of pump needed depends on the spray job. Some jobs are done best with low-pressure and high-volume spraying. Others require high pressure and low volume. The size of the job--the number of acres, plants, or trees to be sprayed--is an important factor.

COMPARISON OF SPRAYER PUMPS AVAILABLE

Type	Materials Handled	Durability	Operating Range (rpm)	Capacity in gallons/min. at zero psi (approx.)	Maximum pressure in psi (approx.)
Roller.....	Almost any (with proper rollers)	Spraying pressure de- creases with water, but worn rollers are easily replaced.	300 to 1,000	1 to 35	250 to 350
Piston.....	Any	Long life	100 to 600	1 1/2 to 60	800 to 1,000
Centrifugal..	Any	Long life	1,200 to 3,500	0 to 120	200
Diaphragm....	Any	Long life	200 to 1,200	1 to 10	100
Gear	Oil emulsions and non-abrasives. Not for wettable powders except when gears are of nylon.	Limited life under ad- verse conditions. Spraying pressure and capacity de- creases with wear.	500 to 1,800	5 to 20	100
Flexible impeller...	Wettable powders, mild abrasives.	Moderate	500 to 1,500	0 to 30	50
Sliding vane rotary....	Limited to oil and oil emulsions.	Spraying pressure and capacity decreases with wear.	500 to 600	5 to 20	125

Spraying recommendations vary with different crops, and may even vary for a particular crop. For example, on one crop, two different systems may be necessary:

Disease control might require spraying pressure of 200 to 400 pounds per square inch (psi) and an application rate of 75 to 150 gallons per acre (gal/A), and weed control may require spraying pressure of 40 to 80 psi and an application rate of 10 to 20 gal/A.

TANK

Sprayer tanks may be made of metal or fiberglass.

Factory-assembled sprayer units usually have a metal tank, coated inside with a chemical-resistant material. The tank usually has rounded corners inside to facilitate cleaning.

On farm-assembled units, the use of one or more 55-gallon drums is common. This reduces the cost of the sprayer, but the drums are more difficult to clean and usually less resistant to rust and chemicals than are tanks designed especially for sprayers. The drums may be mounted horizontally or vertically on a tractor or trailer.

Sprayer tanks should have a large covered opening in the top, fitted with a removable strainer to make filling, inspection, and cleaning easier. A drain plug should be in the bottom to permit complete drainage when cleaning.

Capacity of the sprayer tank on commercially available units is usually 10 to 20 times the pumping capacity of the pump. For example, a 20-gallon per minute (gal/min) pump would have a 200 to 400 gallon tank.

AGITATION OF SPRAY MATERIAL

The two methods of agitating the spray material in the tank are:

Mechanical--agitation provided by paddles or propeller; and

Hydraulic--agitation provided by the return flow of excess spray material from the pump.

Continuous, positive agitation is necessary in order to use the full range of spray materials. Mechanical agitation is considered better than hydraulic agitation. Excessive agitation of certain solutions and emulsions may cause foaming, heating, or other undesirable results. The label on the pesticide container may indicate the kind of agitation to use.

Mechanical agitation is usually provided with piston-type pumps and engine-run sprayers. Hydraulic agitation is often used with sprayers that have the pump driven by power take-off.

DISTRIBUTION SYSTEM

The four types of spray-distribution units are hand guns, automatic spray heads, spray booms, and boomless nozzles.

Hand guns are used for spraying fruit trees and livestock, for spraying in buildings, and for spraying herbicides along fence rows and industrial rights-of-way. They consist of one or more nozzles in a suitable mounting and a fast-acting control valve. The valve serves as a cutoff and as a means of adjusting the spray pattern. Some guns may have two valves--one for cutoff and the other for adjusting the spray pattern.

Automatic spray heads are sometimes used for orchard spraying. The nozzles are arranged on a vertical boom or series of booms.

Spray booms are designed for spraying field and row crops. They consist of a pipe or tubing on which nozzles are spaced and mounted. (The pipe or tubing can be a part of the system that supplies spray to the nozzles.) Nozzles are usually mounted horizontally on the sprayer and can be raised or lowered. The most common boom lengths for field spraying are 18 and 21 feet. Longer booms 30 feet and more in length are available.

Modified spray booms include single nozzles or sets of nozzles for band and directional spraying. Often one to four nozzles may be mounted on slides, skids, or wheels for controlled differential placement of pesticides in emerged crops.

Boomless nozzle, or broadcast, units consist of a single nozzle or a compact arrangement of nozzles mounted at the rear of a sprayer. They deliver a wide-swath spray pattern to a distance of 18 feet or more on one or both sides of the sprayer. They are less expensive, simpler to operate, and require less maintenance than boom units. However, accurate placement of the spray and uniform coverage of an area are difficult to obtain, because the slightest wind affects the spray pattern. The units are most effective in spraying herbicides along roadsides, ditchbanks, and fence rows. High-gallage application rates are required.

NOZZLES

The nozzles determine the angle of spray, the type of spray pattern, the spray droplet size, and the rate of discharge.

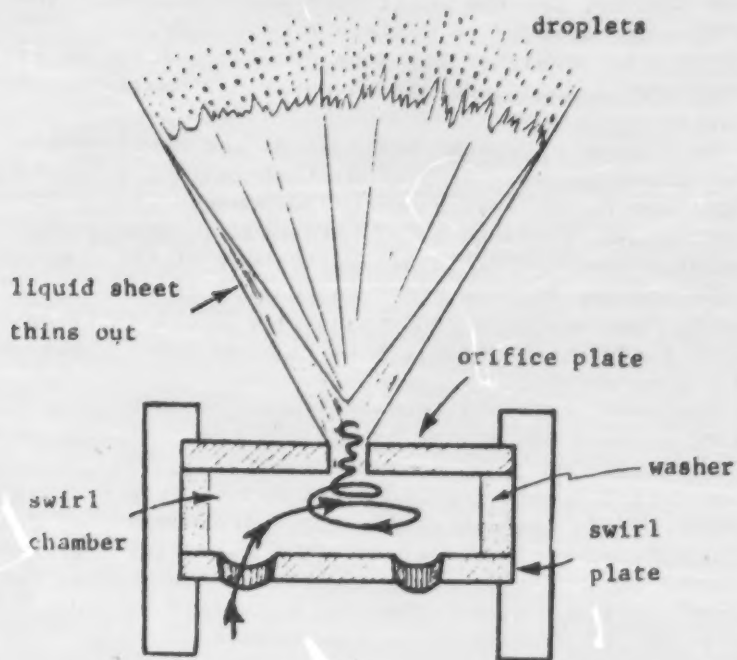
One set of nozzles may be adequate for a field sprayer. The spray pattern and angle and the discharge rate can be varied by changing the replaceable tips or disks. Nozzle manufacturers furnish charts showing the discharge rate of the different tip or disk combinations at different spraying pressures.

Spray pattern may be flat fan, hollow cone, or solid cone. The flat-fan pattern is commonly used for field crop weed spraying. Both the cone and flat-fan patterns are used in insect control.

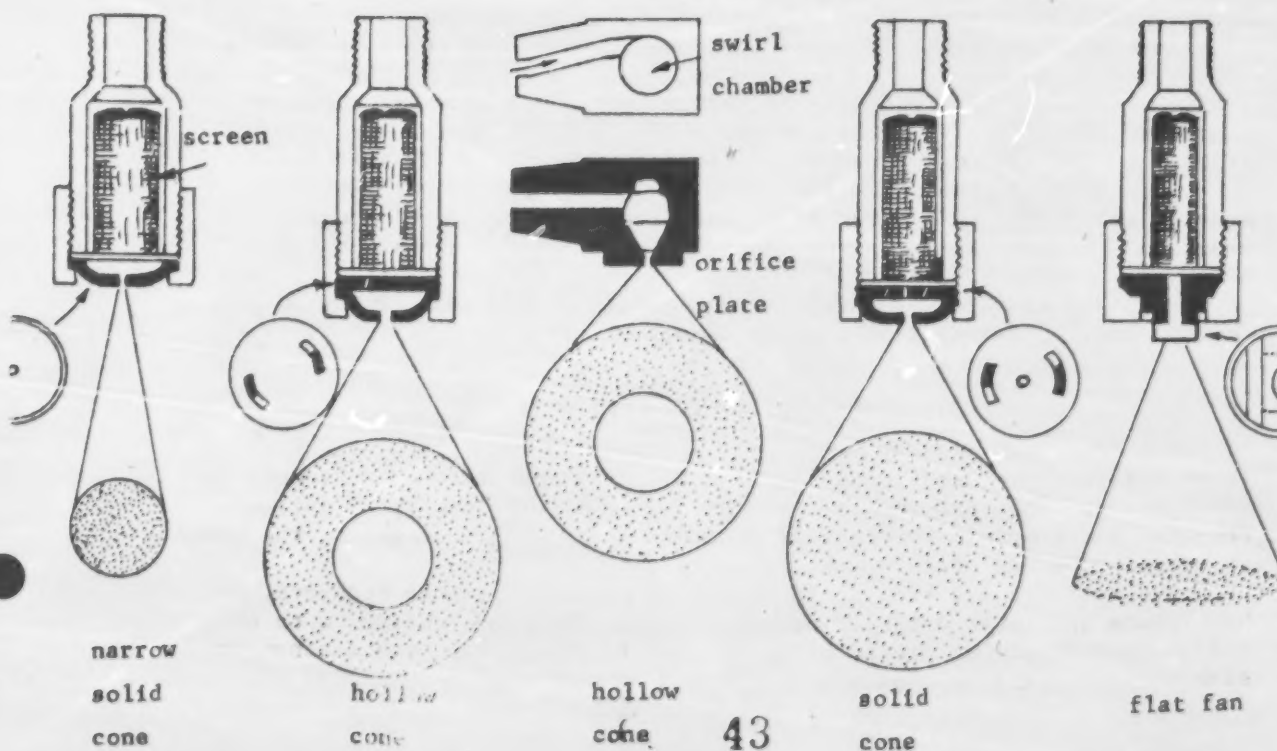
Metal, ceramic, and nylon nozzles are available. Stainless steel, hardened steel, or ceramic nozzles and tips or disks should be used to spray abrasive wettable powders.

Nozzle extensions or drop pipes are available for more accurate placement of the spray and for underleaf coverage in row-crops. Special kits may be obtained for attaching nozzles on a planter for preemergence weed control band spraying.

CROSS-SECTION OF A HOLLOW-CONE NOZZLE



SPRAYER NOZZLE PATTERNS



SMALL GENERAL-USE SPRAYERS

These sprayers include the power wheelbarrow sprayer, the "estate" or small wheel-mounted sprayer, and the small skid-mounted units. The last two are essentially the same sprayer on different mountings.

The sprayers are designed for jobs too large for hand equipment. Jobs for which they are used include garden spraying, small tree spraying, and nursery spraying.

Power wheelbarrow sprayers--smallest of the power-sprayer units--have reciprocating pumps (plunger or piston) that deliver 1 1/2 to 3 gallons per minute and develop pressures up to 250 pounds. Power is supplied by an air-cooled engine of 2/3 to 1 1/2 horsepower. (For greenhouse or other interior spraying jobs, a 1/2 to 3/4 horsepower electric motor can be used to operate the sprayer.) Tank sizes range from 12 to 18 gallons. Spray material in the tank may be mechanically or hydraulically agitated. Standard equipment includes adjustable hand gun and hose. Spray booms are available for some models.

Estate sprayers are small two-wheel mounted units that can be moved by hand. Trailer hitches for moving by vehicle are available as special equipment. Smaller models of these sprayers have 15- to 30-gallon tanks and pumps that deliver 1 1/2 to 3 gallons per minute at pressures up to 250 pounds. Larger models have 50-gallon tanks and pumps that deliver 3 to 4 gallons per minute at pressures of 250 to 400 pounds. Power is supplied by an air-cooled engine of 3/4 to 1 1/2 horsepower. Spray material in the tank is mechanically agitated. Standard equipment includes hand gun and hose; spray booms are available for some models.

MULTIPLE-PURPOSE FARM SPRAYERS

These sprayers are designed to handle all or most of the spraying needs on farms--from low-pressure weed or row-crop spraying (30 to 50 pounds) up to higher pressure fruit-tree, field-crop and livestock spraying (200 to 400 pounds or more.)

The sprayers have plunger- or piston-type pumps that deliver 3 to 8 gallons per minute at pressures up to 800 pounds. Tanks range in size from 50 to 200 gallons. The spray material is mechanically agitated.

Skid-mounted models are powered by an auxiliary engine. Wheel-mounted models may be powered by an auxiliary engine. Wheel-mounted models may be powered by an auxiliary engine or by tractor power take-off.

Hand gun and hose are standard equipment; field booms, 20 to 30 feet in length, are available as optional equipment.

HIGH-PRESSURE, HIGH-VOLUME SPRAYERS

These sprayers are used primarily by commercial applicators or growers for truck crops. They provide the high-pressure, high-volume spray delivery required for complete coverage of fruit trees in full foliage and the dense growth of vine and other truck crops.

The sprayers are similar in design to multiple-purpose sprayers, but have pumps and tanks with larger capacities. The pumps deliver 8 to 60 gallons per minute at pressures as high as 1,000 pounds. Tanks range in size up to 600-gallon capacity.

Field booms designed for use with these sprayers may be the adjustable type or of special design for use on one specific crop.

Hydraulically operated one-side booms are often used to reduce soil compaction (caused by the weight of the sprayer) that might injure the roots of potatoes, tomatoes, and other plants.

Hand guns or automatic spray heads are used for fruit-tree spraying.

LOW-PRESSURE, LOW-VOLUME SPRAYERS

These sprayers are designed primarily for 3 to 50 gallons-per-acre application at less than 100 pounds pressure for insect, disease and weed control in crops.

The sprayers usually have rotary-type pumps, and the spray material in the tank is hydraulically agitated. This limits their use to sediment-free spray materials.

Tractor-mounted models consist of a kit of component parts (pump, valves, pressure gauge, pressure regulator, spray boom, and brackets for mounting the boom and one or more metal drums) which mount on the tractor. The pump mounts on the tractor and is operated by tractor power take-off.

Wheel-mounted models may be operated by tractor power take-off or by a separate engine. They may have a conventional sprayer tank of 50- to 250-gallon capacity or one or more 55-gallon metal drums mounted on the trailer frame.

SELF-PROPELLED, HIGH-CLEARANCE SPRAYERS

These special-purpose machines are designed for spraying field and row crops that are too tall for conventional sprayers.

They consist of two basic units--a vehicle (or carrier) and a sprayer. The vehicle may be a tractor modified to clear plants 5 to 8 feet tall or it may be a specially designed, self-propelled chassis.

Units designed around a tractor usually have a multiple-purpose, skid-mounted sprayer, which is attached to the frame. They may have three or four wheels, with the power at the rear wheels.

Chassis-type units usually have a low-pressure, low-volume sprayer, powered by a separate engine. They usually have three wheels, with the power at one front wheel.

The spray boom is usually mounted on the rear of self-propelled, high-clearance sprayers, and it can be raised or lowered to permit spraying of high- and low-growing crops.

FOG APPLICATORS

Fog applicators, or aerosol generators, are not commonly used on field crops because of the type of spray produced. They are used mostly for temporary control of mosquitoes, flies, and other insects outdoors or in buildings and for pest control in green-houses.

The sprayers produce a fog, or mist, that remains in the air. The fog must contact the pest to be effective, since there is little or no residual action.

Outdoor applications are usually made at night when temperature, humidity, and wind conditions are most favorable. An application cannot be made under excessive wind conditions, but some air movement is required to disperse the spray over the area to be treated.

POWER DUSTERS

Power dusters are seldom used. They are usually classified by the method of powering--engine or tractor power take-off. They may also be divided into two general types--single-outlet units (one hose and nozzle) designed for orchard dusting, and multiple-outlet units designed for field- and row-crop work. Power dusters in general have these essential parts: Dust hopper with agitator and adjustable feed regulator, fan, distribution system (hose and nozzles), and power source.

The units available differ in the type and capacity or size of components, method of powering, and method of mounting.

DUST HOPPER

Dusters are available with hoppers that can hold from 2 to 4 cubic feet. Capacity of the hoppers is 60 to 200 pounds of dust, depending on the density of the dust.

Most units are equipped with internal-type agitators.

The feed regulators are adjustable to deliver dust at rates between 5 and 50 pounds per acre.

FANS

Centrifugal-type fans are commonly used on power dusters. The fan case is fitted with one or more outlets, the number depending on the number of hoses attached.

The fans generally operate at speeds of 2,200 to 3,400 revolutions per minute and deliver 500 to 1,000 cubic feet per minute of air at velocities of 50 to 100 miles per hour.

DISTRIBUTION SYSTEM

Fruit-tree dusters usually have one discharge hose and nozzle. Vineyard units have two hoses and nozzles.

Field- and row-crop dusters may have 4, 6, or 8 hoses and nozzles; some may have as many as 18. Outer ends of the hoses are mounted and spaced on a metal boom, 18 to 20 feet in length. The boom can be raised or lowered, and can be folded for transport.

For field-crop dusting, a tubular-type boom, 20 to 40 feet in length, is often used. It may have a series of discharge holes spaced on the bottom side or it may have an adjustable outlet slot.

Accessories are available for more effective dusting. Hose-support rods, for example, permit better dusting of low-growing crops and better underleaf coverage of rows.

MOUNTING

Engine-powered units may be mounted on a tractor or trailer or transported by truck or other vehicle. Units powered by tractor power take-off may be tractor or trailer mounted.

CALIBRATION

Before starting a dusting operation, check the application rate of the duster unit. Dust mixtures vary in density, and the application rate can vary at a given setting of the feed regulator.

Follow this procedure:

1. Measure off an area of at least 1/2 acre (21,780 square feet).
2. Fill the dust hopper and set the feed regulator for the desired application rate.
3. Dust the measured area. Drive at a constant rate of speed, because rate of speed affects the application rate. A tractor speedometer is recommended.
4. Refill the hopper from a weighed amount of dust. Subtract the weight of the remaining dust from the weight of the original amount. This gives the amount required to fill the hopper, and therefore the amount applied to the measured area.

AERIAL EQUIPMENT

(AERIAL APPLICATION MUST BE DONE BY A LICENSED AERIAL APPLICATOR)

The key to successful aerial application of pesticides is UNIFORMITY of the initial spray deposit over the plant canopy. The chemical will be redistributed by dew, rain, or overhead irrigation to other parts of the plant including lower leaf surfaces, stems and fruit. The key to uniform aerial application is the DESIGN and ADJUSTMENT of the spray distribution system and the OPERATION of the aircraft.

The advantages are summarized below. Most important is the speed of coverage to combat widespread and fast developing epidemics when they strike major crops such as corn, cereal grain, potatoes, and vegetables. One aircraft can do more work in an hour than most ground rigs can do in a day. Aircraft can spray fields that are too wet for ground equipment, which is often the case when fungus pests are most active.

ADVANTAGES OF AERIAL APPLICATION

1. Faster
2. Better timing
3. Works on wet fields following rain or irrigation
4. Only feasible way to cope with pest epidemics
5. Eliminates sprayer wheel damage and soil compaction
6. Reduces mechanical spread of virus and bacterial disease
7. Spray deposits resist weathering better
8. Uses less water
9. No runoff
10. Lowers grower's capital investment
11. Reduces labor requirements

DISADVANTAGES OF AERIAL APPLICATION

1. Some fields inaccessible or too uneven for successful flights
2. Inherent potential for environmental pollution and drift damage
3. Certain crops not suited to aerial application

EQUIPMENT AND OPERATION

AIRBORNE-AIRBLAST SPRAYER

To consider an agricultural aircraft an "airborne-airblast sprayer" will put its function into better focus. Its efficiency depends on its adjustment and operation. The airstream from a fixed wing aircraft or helicopter moves outward and downward. The objective is to put the spray into this stream of air in such a manner that it comes out uniformly across the crop when spraying is completed. Swaths must overlap properly. The upper canopy of foliage is a primary target for insects and diseases of most crops. Penetration of vertical distribution will be adequate for most crops, except in unusual situations.

SWATH WIDTH

Most aircraft in calm air will disperse some spray to a width about twice that of the wingspan. The effective swath width is governed mainly by the weight and wingspan. Tight swaths give better lateral surfaces, perhaps even to the undersides of leaves. For most field and vegetable crops, swaths at just beyond the wingspan of 36 to 40 feet for light aircraft and up to 45 feet for heavier craft are suggested. Optimum swath for helicopters is usually 5 to 10 feet beyond the normal boom length.

FLAGGING

Swaths should be marked at the end of the field with permanent flags or by a flagman. Swaths should be measured accurately with a chain or other device except when rows can be accurately counted. Test plots should be at least three swaths wide to avoid mixing of treatments.

SPRAY VOLUME

Experience has shown that the volume of aerial spray can be reduced significantly with no real loss in disease control. Whereas five to ten gallons per acre was considered minimal a few years ago for field and vegetable crops, volume of two and three are now used successfully. This necessitates well-designed and operated spray systems of either boom-nozzle or Micronair types. The water or other liquid vehicle in the spray serves no other function than to keep the mixture fluid until it is delivered to the target on the plant. Only sufficient water is needed to make the chemical sprayable. On vegetables and field crops, two to three gallons of spray volume per acre is considered optimum. Most orchard crops and vineyards can be handled with volumes up to five gal/A. Some very unusually tall or dense foliage crops or situations requiring greater penetration to the lower surfaces may benefit from slightly higher volumes, if aerial application is at all feasible. A slight increase in normal volume may be desirable under unusually low humidity conditions if some type of non-volatile carrier cannot be used. Spray volume is not nearly as important as the uniformity of the distribution of the chemical into the airstream of the aircraft.

SPRAY ADJUVANTS

The initial spread and coverage of the spray can be enhanced with a spreader-sticker on many hard-to-wet crops because they are smooth, waxy, or hairy. Properly chosen, such materials, sometimes known as surfactants, will greatly improve initial retention and will also aid redistribution without excessive runoff. Certain emulsifiable spray oils have also been used to advantage with aerial sprays. They improve spreading, tenacity, and redistribution and tend to reduce the evaporation of the spray in flight.

Ordinary household detergents or herbicide spray adjuvants are not recommended as agricultural spray adjuvants. They may cause too much foam, excessive runoff, and may lower the tenacity of the spray deposit.

TYPE OF AIRCRAFT

Any of the commonly used makes and models of fixed wing or rotary agricultural aircraft will work if they have a good spray distribution system and are operated within their airmoving capacity. This is determined mostly by wingspan, weight, and speed. The aircraft is nothing more than the vehicle to haul the load. The choice will be governed by the type of operation and to a large extent the preference of the operator.

SPRAY DISTRIBUTION SYSTEMS

Boom-nozzle or Micronair Rotary Atomiser sprayers are satisfactory for most fungicides and insecticides. Ultra-low-volume application such as "Mini-Spin" equipment is adaptable to certain insecticides but not fungicides.

BOOM-NOZZLE SYSTEMS

The majority of aircraft are equipped with boom-nozzle spray distribution systems. Either wing-enclosed or trailing-edge booms are satisfactory. Some homemade ones are a "plumbers nightmare."

NOZZLE SPACING AND PLACEMENT

On most aircraft, including helicopters, nozzles must be positioned asymmetrically (irregularly) on the boom, clustered or spread out as required at certain points to compensate for the distortion of the airstream by the propeller or from secondary eddies caused by the fuselage or wheels.

The larger the engine and propeller the greater the distortion will be. Regular or symmetrical spacing of nozzles produces a streaked, uneven pattern except on light, high-winged monoplanes. Many "customized" booms, especially after modifications according to the fancy of the operator, put out a very irregular spray pattern. Factory-installed booms with clustered nozzles as used on "Pawnees" and "Agcats" usually provide a uniform spray pattern. Unfortunately some new models of agricultural aircraft, although they are efficient aerial vehicles, are coming out of the factory with poorly designed spray booms (symmetrical and wingtip nozzles) that will require major modification and nozzle relocation. Most helicopters require minor clustering of certain nozzles to even out the pattern.

WINGTIP VORTICE

All aircraft produce a certain amount of vortice roll at the end of the wings or rotorblades. This can be used to advantage in aerial spraying if the spray released into the entrained air can be kept under control. If the boom is too long on a fixed wing aircraft, too much of the spray may be dispersed into upper air currents where it will be lost and subject to excessive drifting. To prevent this, nozzles should not be used within two to three feet of the wingtip. The so called "high-capacity booms" with nozzles to the wingtip or beyond may be used for high-altitude, wide-

swath, drifting-type application of insecticides to forest trees, but are not recommended for applying fungicides. Similarly, if the boom on a helicopter is too long, some spray will be released beyond the effective force of the rotor tip vortices. Helicopter booms should be only a few feet longer than the span of the rotors.

NOZZLE TYPE

Hollow-cone nozzles such as Spraying Systems No. 4664 Diaphragm TeeJet fitted with a core (whirlplate) and orifice disc are recommended. "Whirl-jet" or flat-fan nozzles are not recommended because they are highly subject to wear and soon produce irregular droplet patterns. Discs and cores of cone nozzles are easily and economically replaced when worn.

NUMBER AND SIZE OF NOZZLES

For spray volumes of 2 to 4 gal/A, 20 to 30 well-placed nozzles are adequate. For volumes of 5 to 10 gal/A, 30 to 44 properly spaced nozzles are suggested. D-4 and D-6 with No. 45 cores are suggested for the lower volumes. D-8 to D-12 with No. 45 or No. 46 cores will be required for the high volumes. The final choice of the number and size of the nozzles depends upon the airspeed, pressure, and volume desired. Preliminary calculations can be made from manufacturer's nozzle capacity charts. Sizes can be mixed to change the output at strategic spots on the boom.

CONTROLLING DROPLET SIZE

The shear forces of the air passing over the face of the nozzles exert a far greater influence on droplet size than the pressure, airspeed or size of orifice used in normal application. The droplet size can be altered considerably by changing the angle of the nozzle into the airstream. The spray volume remains the same with no change in pressure or orifice size.

Nozzles pointing straight down or slightly backward will approximate the desired breakup of the spray for insecticide or fungicide application. Slightly smaller discs or higher pressures may be necessary on helicopters because of the slower flying speeds.

Nozzles pointing forward usually cause too much breakup and create droplets that are too fine and subject to drifting.

The nozzle pointed backward produces a very coarse spray, more subject to streaking and uneven coverage.

Changes in the nozzle angle can be made quickly on the entire boom if it is fitted with a flexible coupling and adjustable mounting. Streamlined or fixed booms that cannot be turned can be adjusted by turning the individual nozzles sideways or downward to the desired angle.

PUMPS AND PRESSURE

High-capacity pumps with one- or two-inch discharge are desirable on aerial sprayers for the relatively high volume and bypass agitation required for wetttable powders. Operating pressures usually range between 25 to 50 psi for nozzle systems. With soluble materials or emulsions, less agitation is needed.

MICRONAIR ROTARY ATOMISER

This equipment has been used very successfully with pesticides on a large variety of crops. The individual units consist of propeller-driven rotating wire mesh cylinders. The spray mixture is pumped at low pressure to a central spindle and is discharged by centrifugal force. Droplet size is readily changed by adjusting the variable pitch blades on the units. The faster the rotation the finer the droplets. Droplet size remains relatively consistent regardless of the volume of spray being applied per acre. The delivery rate is altered quickly by adjusting the bypass or flow rate of the pump. The earlier standard model consisted of five rotating cages. The new compact model, AU3000, with two cages, is lighter in weight. It can apply adequate gallonage for fungicides, yet is readily adapted to ultra-low volume insecticide use.

The Micronair Rotary Atomiser produces droplets of a more uniform size than a conventional nozzle. Spray volume of two to three gallons per acre is standard for Micronair and usually somewhat lower than boom-nozzle systems. Four atomisers are suggested for standard aircraft and six for the larger. Operating swath widths are the same as conventional boom systems on a given aircraft. Slightly higher flying altitude is suggested with Micronair equipment to permit full blending of the individual spray streams. Rotary atomizers have a tendency to put out ultra-fine droplets. Operators are cautioned to avoid droplets that are so fine they result in waste and drift hazard. The initial cost of rotary atomizers is higher than a boom nozzle system, but this is offset by economies in operation and maintenance with greater flexibility.

HELICOPTERS

Helicopters equipped with boom sprayers are used successfully for the application of pesticides on a wide variety of crops. They have the distinct advantage of being able to work small and obstructed fields. They do not require airstrips, and considerable ferrying time may be saved. The same gallonage rates recommended for fixed-wing, boom-nozzle sprayers are also recommended for helicopter application. The penetration of dense foliage is excellent with a helicopter at slow to moderate flying speeds. However, at normal operating speeds of 40 to 60 mph, the penetration of foliage has often been overemphasized. It is not necessary except in unusual cases because redistribution of the initial spray deposit corrects the irregularities. Helicopter operators are cautioned not to exceed optimum swath widths and flying speeds for the particular size and weight of helicopter being operated.

CLIMATE AND OPERATING CONDITIONS

WIND

A wind of two to six miles per hour is considered ideal, but aerial applications can be made in steady winds of up to ten to twelve miles per hour with little loss in effectiveness. Suitable adjustments should be made in droplet size under these conditions. Applications should be avoided in gusty winds or during the heat of the day when there are rising thermal air currents. Contrary to popular belief, sprays applied during dead calm and especially under temperature inversions fail to settle properly and may create serious drift problems. For convenience and efficiency, rows are usually planted the long way of the field and flown in the same direction. If there is a choice, a light crosswind during spraying is advantageous to equalize the distribution of the spray within the swath and between swaths and should be used whenever possible. In higher winds it may be better to fly up and downwind.

RAINFALL AND DEW

Sprays may be applied when plants are dry or wet with dew, rain or irrigation. Moisture on the plants at the time of spraying helps spread the initial spray deposit. Rewetting the foliage will redistribute the spray. Where permanent or solid set irrigation systems are installed, the water may be turned on for a few minutes to wet the foliage and then shut off before spraying each particular set.

CHECKING SPRAY PATTERNS

THE IMPORTANCE OF PRE-CHECKING EACH AIRCRAFT FOR DROPLET SIZE, UNIFORMITY OF PATTERN, SWATH WIDTH, AND SPRAY VOLUME CANNOT BE OVEREMPHASIZED. THIS MUST BE DONE BY ACTUAL TESTS.

DROPLETS SIZE AND DISTRIBUTION

A reasonably accurate job of checking the spray characteristics of an aircraft can be done on the airstrip. Some dyes will make a good pattern of pesticide particle size and concentration on semi-smooth finish or sign-stock paper. Highly absorbent composition paper or slick black plastic is not satisfactory. Tapes and strips blow about too much. Cards or small sheets of heavier stock can be stapled or tacked about two feet apart to wood strips and laid across the line of flight. A single pass at normal altitude should be made first. This will show the droplet size range, any gross irregularities in the pattern, and the width or lateral dispersion of the spray. An additional pass on either side at the projected swath width will show the degree and uniformity of the overlap. Corrective changes in nozzle location (uniformity), nozzle angle (droplet size), or swath-width (overlapping) can be made where indicated. Achieving a good spray pattern is largely a matter of trial and error, but pattern studies are necessary steps to accomplish this end.

All airspray equipment should be carefully checked before the active spray season to avoid unnecessary and costly delays or faulty application with improperly serviced and adjusted equipment. Rechecks should be made during the season whenever changes are made in the spray distribution system.

CALIBRATION

The spray volume must be known precisely in order to achieve the proper rate of chemical per acre. Once the swath width is established from the pattern tests and the airspeed is known, further adjustments in volume can be achieved by changing the size of the nozzle discs and whirlplates or the pressure. Manufacturers nozzle specification charts should be consulted to make preliminary selection of nozzles. Calibration may be done by flying over a measured distance or by flying for a given length of time. The details of these methods are given in the following tables.

COMPUTATION OF ACREAGE AND MATERIALS

$$\text{FORMULA: Acres covered} = \frac{\text{Length of swath in miles} \times \text{width of swath in feet}}{8.25}$$

The number of acres in a swath of given width and length can be determined from the chart below.

Example: An aircraft with a 40-foot effective swath treats a strip one mile long. To find the number of acres, follow the 40-foot vertical column down until it intersects the 1-mile line. The answer to the nearest tenth is 4.8 acres. For swath widths other than those shown, interpolate or use combinations of the figures shown.

To determine the amount of pesticide required, multiply the acres by the desired rate of application.

ACREAGE CHART

Swath Length (Miles)	30' Swath	35' Swath	40' Swath	45' Swath	50' Swath	75' Swath	100' Swath	200' Swath	300' Swath	500' Swath
1/4	.9	1.1	1.2	1.4	1.5	2.3	3.0	6.0	9.1	15.2
1/2	1.8	2.1	2.4	2.7	3.0	4.5	6.1	12.1	18.2	30.3
3/4	2.7	3.2	3.6	4.1	4.6	6.8	9.1	18.2	27.3	45.4
1	3.6	4.2	4.8	5.5	6.1	9.1	12.1	24.2	36.4	60.6
2	7.2	8.4	9.8	10.9	12.1	18.2	24.2	48.5	72.7	121.2
3	10.8	12.6	14.5	16.4	18.2	27.3	36.4	72.7	109.1	181.8
4	14.4	16.8	19.4	21.8	24.2	36.4	48.5	97.0	145.4	242.4
5	18.0	21.0	24.2	27.3	30.3	45.5	60.6	121.1	181.8	303.0

AIRCRAFT CALIBRATION

$$\text{FORMULA: Acres per minute} = \frac{2 \times \text{swath width} \times \text{miles per hour}}{1,000}$$

The chart below shows the rate, in acres per minute, at which spray or dry material can be applied when swath width and speed of aircraft are known. For swath widths or aircraft speeds other than those shown, interpolate or use combinations of the figures shown. To find the rate of flow in gallons per minute or pounds per minute, multiply the acres per minute by the number of gallons or pounds per acre to be applied.

Example: A 100 mile-per-hour aircraft has a 40-foot effective swath. Follow the vertical 40-foot column down until the figure opposite 100 miles per hour is intersected. The aircraft would cover 8.0 acres per minute. If 1 gallon of spray is to be applied per acre, the aircraft should be calibrated to disperse liquid at the rate of 8 gallons per minute. If 10 pounds of dry material is to be applied per acre, the aircraft should be calibrated to disperse material at the rate of 10 x 8.0, or 80 pounds per minute.

ACRES-PER-MINUTE CHART

Speed M.P.H.	30' Swath	35' Swath	40' Swath	45' Swath	50' Swath	75' Swath	100' Swath	200' Swath	300' Swath	500' Swath
75	4.5	5.2	6.0	6.7	7.5	11.2	15.0	30.0	45.0	75.0
80	4.8	5.6	6.4	7.2	8.0	12.0	16.0	32.0	48.0	80.0
85	5.1	5.9	6.8	7.6	8.5	12.7	17.0	34.0	51.0	85.0
90	5.4	6.3	7.2	8.1	9.0	13.5	18.0	36.0	54.0	90.0
95	5.7	6.6	7.6	8.5	9.5	14.2	19.0	38.0	57.0	95.0
100	6.0	7.0	8.0	9.0	10.0	15.0	20.0	40.0	60.0	100.0
110	6.6	7.7	8.8	9.9	11.0	16.5	22.0	44.0	66.0	110.0
120	7.2	8.4	9.6	10.8	12.0	18.0	24.0	48.0	72.0	120.0
130	7.8	9.1	10.4	11.7	13.0	19.5	26.0	52.0	78.0	130.0
140	8.4	9.8	11.2	12.6	14.0	21.0	28.0	56.0	84.0	140.0
150	9.0	10.5	12.0	13.5	15.0	22.5	30.0	60.0	90.0	150.0

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SPRAYERS AND PESTICIDE APPLICATION EQUIPMENT FOR TURF

SPRAYER SELECTION

No one commercial-size sprayer now available can meet all the demands of the turfgrass industry. For any specific task, many sprayers are suitable. It takes an understanding of types available, capabilities, types of mounting, power sources, pumps and tanks, guns and hoses, blowers, and other accessories, to make a wise choice.

Most power sprayers in use today can be classified as one of two general types--the hydraulic sprayer or the air-stream mist blower. Both types have these basic sprayer elements in common: tank with agitator; pump with pressure regulator; unloader or relief valve and pressure gauge; power source; self-contained engine or power take-off connection; framework for mounting the sprayer; strainers, screens, and control valves; and interconnecting piping, including leads to the distribution system.

The distribution system of the two types, however, is fundamentally different, each having characteristics which make it preferred for specific spray jobs. In hydraulic sprayers, the spray material is usually distributed through a hand-held nozzle gun, or through a multiple-nozzle spray boom, or both. The force or energy required to carry the spray droplet from a hand gun to distant foliage comes from the pressure developed by the direct action of the pump on the spray liquid.

In the air-mist sprayer, the distribution system contains a fan or blower which creates a continuous blast of air to carry the spray droplets from the nozzle to the surface to be treated. This air blast can be directed upward or downward to spray hillside turf, or horizontally for mass coverage of level turf. The air-mist sprayer is known as a concentrate sprayer, because the use of the air stream as the propelling and dispersing force permits the use of spray materials in concentrated form. This results in significant savings in hauling and handling water.

HYDRAULIC SPRAYERS

Hydraulic sprayers are available in a large variety of choices of types and models, and with many accessories. Consider the types of jobs you must do and then select the most appropriate sprayer; larger or smaller jobs may require different sprayers.

One of the larger sprayers (when equipped with the usual 20-foot spray boom) would cover about 10 acres of golf course fairways or other turf in one hour of travel at 4 miles per hour. If this were an application of herbicide, which is usually put on at the rate of about 10 gallons per acre, the sprayer would apply about 100 gallons of spray material per hour. Assuming the fairway covers about 3 or 4 acres, the sprayer, equipped with a 200-gallon tank, would have to be filled about twice to cover the weeds on the fairways of a nine-hole course. Booms and nozzles are easily modified in most instances.

Since turf spray is often applied at pressures of 40 to 60 pounds per square inch, a 5-gallon-per-minute pump would be adequate for the 20-foot boom since it would require only 2 gallons per minute equipped and operated as described.

Some turfgrass managers select larger than minimum-size pumps to provide greater flexibility for other uses. With such a pump and higher pressure capacity, the sprayer may be suitable also for shade tree spraying, with some limitations. The maximum reach with any long distance hand gun, and most nozzles, is obtained at pressures of about 250 pounds per square inch at the nozzle. At higher pressures, the spray droplets are broken up finer and tend to drift. At a pressure of 250 pounds per square inch, a sprayer equipped with a pump capacity of 5 to 10 gallons per minute would be able to reach the top of 40- to 45-foot trees.

Two important points to consider in selecting the hydraulic sprayer best suited for the types of jobs to be done are mounting and power source.

MOUNTING

Self-contained units are commonly mounted on two-wheel trailers. Those with extra-large tanks may require oversized tires or four wheels. The same basic units are also available on skid mounting for transport on a truck or other vehicle. Some special units are designed for direct mounting on the rear of a tractor with a three-point hitch.

The choice between trailer and skid models will depend on the frequency of use of the sprayer, the types of jobs to be handled, and the possible additional use of vehicles or tractors available for transporting them. Skid models mounted on flat-bed trucks are most often used in large-scale tree spraying or roadside turf weed spraying. On large golf courses, a unit widely used is the trailer-type which can, if desired, be powered from the tractor power take-off. New skid models which fit special golf course vehicles are handy for frequent greens maintenance. A permanent hoisting mechanism for easy loading and unloading of skid models is desirable.

POWER SOURCE

Trailer-mounted sprayers are often powered by the power take-off from the tractor. This saves initial investments in engines; however, a self contained power source allows sprayer use with any vehicle that can pull the sprayer.

AIR-STREAM MIST BLOWER SPRAYER

The use of air as a carrier for spray chemicals began in the 1920s with the introduction of boom-type row crop dusters. Large strides in air spraying were made after 1946. The success of concentrate sprayers in orchards created interest in the use of this equipment for other crops. Interest in air-mist sprayers on golf courses is increasing every year. However, these sprayers are NOT suitable for herbicide application due to drift hazard.

Early research conducted at the Ohio Agricultural Experiment Station in co-operation with the United States Department of Agriculture showed that effective control with air spraying can be achieved with:

1. Effective spray materials
2. Adequate amounts of chemical
3. Accurate timing of applications
4. Even and thorough distribution of chemicals on and throughout the foliage canopy

These same factors are equally important for hydraulic boom spraying. Since acreage covered per day is higher with air equipment, more effective timing is possible with air machines. However, the basic problem is distribution of material and the effect of wind conditions on even and thorough distribution.

To attain the same utility level as boom equipment, air sprayers must be able to operate in wind conditions. To justify the additional investment, they must reduce overall spraying costs as well as achieve pest-control levels comparable to hydraulic booms.

Subsequent research has verified that these goals are suitable if:

1. Effective area to be sprayed is limited to that point in the air jet where air velocity is no less than 15 to 17 miles per hour. (Spray material must be driven into the foliage with turbulent force.)
2. Air-spraying equipment in question is able to handle chemicals in suspension as well as liquid emulsions.
3. A satisfactory deposit is obtained on the side sprayed into the wind.
4. The spray swath is not over-extended. With the smaller air sprayers, a wider swath is attained than with the largest spray booms. Even with this advantage, many people tend to over-extend the swath reach of these machines. A certain amount of overlap should be allowed at the swath extremity for effective control.

Two primary types of air sprayers exist: the one-way turntable outlet, and the fixed two-way discharge. Each has advantages. The advantages of the one-way outlet are limited to the smaller machines (up to 60-foot swath). For swath widths of more than 60 feet, the two-way sprayer will consistently deliver the spray deposits required to justify the investment in the larger sprayer.

Total air jet throw is 40 percent greater when a given volume of air (at the same velocity) is divided and discharged from two outlets in opposite directions when it comes from one source.

For effective pest control the spray should be driven into the turf foliage with turbulent force. The effective swath is the length of the moving air column where air velocity is 17 miles per hour (1500 feet per minute) or more.

The larger one-way sprayers often depend on the wind to drift the swath to its advertised width. Spraying with the wind usually causes the deposit to be dropped onto the foliage rather than driven into it, at the swath extremity. If the distance of the swath from a one-way machine is extended beyond recommendation, a lower velocity of air reaches the swath, causing the larger, heavier droplets to settle short of the target.

The longer an outlet in relation to its width, the greater the intake of free air surrounding the outlet. As more air is taken into the jet stream, the jet velocity is reduced; consequently, the air jet throw is decreased.

One very important factor, easily overlooked, is the shape of the air outlet. Surrounding free air, induced into the jet stream, reduces the velocity of the air pattern. Hydraulically, the most efficient outlet shape is circular.

Wind velocity increases with height. The outlet on some sprayers is mounted high and is located in this high-velocity wind area. On other sprayers, the air outlet is placed low, thus removing it from high-velocity wind area. Angling air-discharge vanes down produces an air stream beneath this high-velocity area, and will consistently produce wider spray swaths in windy conditions. The resulting rolling air pattern gives superior coverage on both sides of the grass leaf, and may even give better control on the prevailing up-wind side.

Many factors have to be considered when determining the work rate of air sprayers. Variables such as type of terrain, ground speed, wind, and fairway length and width all have a bearing on the spray rate.

Sprayer performance is only one factor in a total pest-control picture. Weather, chemical effectiveness, and operator's skill are all important.

The three most common mistakes in air spraying techniques are:

1. Excessive rates of travel.
2. Over-extension of swath reach.
3. Lateral or upward air discharge rather than downward into the turf foliage.

The correct rate of travel is very important since it has an effect on the total swath reach. Generally, the rate of travel should be limited to 1 1/2 to 2 miles per hour. An operator should frequently check the deposit over the swath to make sure that sufficient coverage is being obtained. If coverage is questionable, the rate of travel or the coverage spacing should be reduced.

Some applicators in extremely flat sites resort to night spraying to reduce the wind factor. This may not always be practical, but certainly extends the availability of equipment. A spotlight, mounted above the air outlet and directed laterally, allows a continual check of the spray swath.

Air pattern control vanes should be adjusted downward to direct the air jet under the wind and into the foliage. Many applicators have found that they obtain consistently longer swaths this way and no longer need to make in-travel adjustments of the vane angle.

For most golf turf areas, the sprayer should travel down one side and back the other with the spray pattern overlapping the center.

The most commonly used spray volume dilution is 40 gallons per acre. A practical downward limit is probably 10 gallons per acre.

Although fine droplets are necessary to obtain adequate distribution with low gallonages, they must be large enough to give a deposit on foliage. This balance between droplet diameter and the deposit obtained, will probably continue to establish the practical minimum volume limit in the range of 10 gallons per acre.

Liquid pesticides are most popular for large areas, but pesticides may be applied dry as granules or dusts, also. Dusts are of little significance, being used less and less each year, especially as turfgrass treatment. Granules may be applied with either drop-gate or spinner spreaders. The drop-gate is somewhat easier to calibrate because it uses a catch pan for full recovery of the trial run material. With spinner spreaders, the calibration is similar except that it may be accomplished by either the refill procedure or by building a specially designed trapping box to catch the complete output from the spinner. Because of the unique physical properties of each granule formulation (depending on the carrier) the spreader must be calibrated with the active pesticide to be used rather than pure water as can be done with sprayers.

DRIFT HAZARD

Spray drift can be a hazard to both the operator and to other persons in the area. With herbicides, especially the hormone-type materials, a severe drift hazard is present to non-target plants.

Two operational techniques will keep drift hazard to a minimum. First, by angling the air pattern downward into the foliage, the smaller droplets will more likely fall on the foliage. This reduces the possibility of wind currents carrying the smaller droplets into non-target areas. Secondly, the target area should always be sprayed from the outside toward the center. This technique eliminates misses in the turnaround area and provides a buffer zone to reduce spray fallout outside the target turf area boundary.

DO NOT APPLY HERBICIDES WITH AIR-MIST SPRAYERS.

Pesticides may be applied in liquid form with helicopter and fixed-wing aircraft. These are primarily of use in sod farm turfgrass production, although helicopter application is beginning to be used more frequently for golf course pesticide treatment. The pilot must be a certified commercial aerial applicator.

LARGE ACREAGE SPRAYER CALIBRATION--OPTIONAL METHODS

I. Method I

- A. Measure out 660 feet.
- B. Determine the amount of spray put out in traveling this distance at the desired speed.
- C. Use this formula:

$$\text{gallons per acre} = \frac{\text{gallons used in 660 feet} \times 66}{\text{swath width in feet}}$$

II. Method II

- A. Fill spray tank and spray a specified number of feet.
- B. After spraying, refill tank and measure the quantity of material needed for refilling.
- C. Use this formula:

$$\text{gallons per acre} = \frac{43,560 \times \text{gallons delivered}}{\text{swath length (feet)} \times \text{swath width (feet)}}$$

III. Method III

- A. Measure 163 feet in the field.
- B. Time tractor in crossing 163 feet. Make two passes to check accuracy.
- C. At edge of field, adjust pressure valve until you catch 2 pints (32 ounces) of spray in the same amount of time it took to run the 163 feet. Be sure tractor is at the same throttle setting. You are now applying 20 gallons per acre on a 20-inch nozzle boom spacing.
- D. For each inch of nozzle spacing on boom, increase time by 5 percent or reduce the volume by 5 percent.

IV. Method IV.

See following tables.

SPRAYER CALIBRATION BY THE QUART-JAR METHOD

Nozzle Distance in Feet Required to Catch One Quart Per Nozzle
At Various Rates of Application

<u>Spacing inches)</u>	<u>5 gallons per acre</u>	<u>7 1/2 gallons per acre</u>	<u>10 gallons per acre</u>	<u>15 gallons per acre</u>	<u>20 gallons per acre</u>	<u>25 gallons per acre</u>
6	4,356	2,904	2,178	1,452	1,089	871
8	3,265	2,180	1,633	1,089	816	652
10	2,610	1,744	1,305	871	652	522
12	2,178	1,452	1,089	726	544	435
14	1,868	1,245	934	624	466	374
16	1,633	1,089	816	544	407	326
18	1,452	968	726	484	363	290
20	1,306	871	653	435	327	261
21	1,245	830	622	415	311	249
22	1,188	792	594	396	297	238
24	1,089	726	545	363	272	218
30	871	581	436	290	218	174
36	726	484	363	242	182	145

SPRAYER CALIBRATION BY THE PINT JAR METHOD

Distance Required to Catch One Pint per Nozzle
at Various Rates of Application

<u>Spacing (Inches)</u>	<u>5 gallons per acre</u>	<u>7 1/2 gallons per acre</u>	<u>10 gallons per acre</u>	<u>15 gallons per acre</u>	<u>20 gallons per acre</u>	<u>25 gallons per acre</u>
6	2,178	1,452	1,089	726	544	435
8	1,633	1,089	816	544	407	326
10	1,306	871	653	435	327	261
12	1,089	726	545	363	272	218
14	934	623	467	312	233	187
16	817	545	408	272	204	163
18	726	484	363	242	187	145
20	653	436	327	218	164	131
21	623	415	311	208	156	125
22	594	396	297	198	149	119
24	545	363	272	182	136	109
30	436	292	218	145	109	87
36	313	242	182	121	91	73

CAUTION: Check output of all nozzles and select an average nozzle by which to calibrate.

GRANULAR PESTICIDE APPLICATION CALIBRATION FOR SMALL-AREA TREATMENT

Dry granular herbicides, fungicides, insecticides, and fertilizers are usually applied with spreaders that meter the formulation through adjustable discharge ports in the bottom of the spreader. Many of these spreaders give approximate settings, because it is practically impossible for a manufacturer to provide accurate rate settings for products other than their own granular materials.

The metered application rate at any given setting will vary for different materials. Density, particle size, and flowability are common material characteristics which vary and affect the application rate. Finely powdered material that tends to pack often can be applied only with those spreading devices equipped with special agitators. If there is a considerable variation from bag to bag in particle size and product density, or if the forward speed of the spreader changes appreciably during application, rates will be affected.

Parts of spreaders, particularly the metering mechanism, will wear. Worn mechanisms require adjustments to maintain the rate of application according to standards or tolerances set by the original manufacturer. This adjustment, or calibration, can usually be done only by instructions from the manufacturer.

Generally, it is necessary to establish a spreader setting that will apply a desired amount of granular material per square foot of soil surface, usually calculated per 100 square feet, or per one acre. This is called "establishing the rate."

Rate Establishment Based on 100 Square Feet

To establish the rate by which granules will spread from an applicator, equipment measurements and a treatment area (100 square feet) must be determined for use as standards.

1. Measure the width of the spreader in feet.
2. Divide 100 by the width; this will give the lineal feet that the spreader must travel to cover 100 square feet.
3. Select an area of turf to be treated and mark off the lineal feet as calculated.

Application Rate Adjusted by Three Methods

Now that a standard treatment area has been marked, the rate of discharge for V-shaped hopper spreaders may be established by either of three methods.

Method 1: Fill the spreader half-way with granules. Weigh both the spreader and the granules and record their total weight. Adjust the spreader's output rate to an approximate setting and operate it over the lineal feet marked for the test plot. Again, weigh the spreader and its contents. Subtract the second weight from the first; the result will be the number of pounds of granules you applied on 100 square feet. If the weight of material applied is more or less than the desired or recommended rate, readjust the spreader's output and make another test run until the correct setting is established.

Method 2: Construct a lightweight metal pan 2 inches deep, 6 inches wide, and of sufficient length to fit between the wheels of the spreader. Drill a hole in each corner of the pan and fasten a piece of wire in each hole. This pan then can be hung beneath the spreader and should catch all of the granules. Next, determine the desired rate of product application (from label or other recommendations) per 100 square feet. Fill the spreader half-way with material and operate it over the lineal distance. Weigh the granules caught in the pan (do not include the pan's weight). If the amount of material is more or less than the recommended rate per 100 square feet, reset the spreader and make another test run until the correct setting is established.

Method 3: Agitators of most hand-pushed spreaders are driven by one wheel only. Find the wheel that drives the agitator and drill a 1/4-inch hole near its outside edge. Fasten a 1/4-inch bolt 3 inches long into the wheel so it can be used later to turn the wheel. Measure the circumference (distance around) of the wheel in feet. Divide this figure into the lineal feet the spreader must travel to cover 100 square feet; this determines the number of wheel revolutions required for the spreader to cover 100 square feet. Now fill the spreader half-way with granules and estimate its rate setting. Place the spreader over a large sheet of paper or cloth; raise the drive wheel side of the spreader about 1/2 inch off the ground. Next, open the spreader, and by using the bolt as a crank, rotate the wheel the same number of turns as required to cover 100 square feet. Crank the wheel at the approximate speed at which it would move under normal applications. Weigh the material on the paper. If the amount collected is more or less than the recommended rate per 100 square feet, reset the spreader and repeat the test until the desired rate is achieved.

Some spreaders are specifically designed and manufactured to apply granulated materials quite accurately. Other spreaders are designed primarily for fertilizer applications where accuracy is not as important. Generally speaking, those multi-purpose spreaders which are made to apply herbicides, pesticides, and also fertilizers are of necessity manufactured for greater accuracy than are typical fertilizer spreaders.

HOSE PROPORTIONER SPRAYER CALIBRATION FOR SMALL AREA SPRAY APPLICATION

Applying liquid pesticides uniformly to a given surface can be done with a special sprayer operated on the end of a garden hose, using adequate water pressure. A hose applicator varies in rate of application depending on water pressure, width of swath covered, and speed of walking. To accurately apply a pesticide, you may calibrate rate of application as follows:

1. Measure off area which has 1,000 square feet.
(For example, this could be an area 100 feet x 10 feet; or 50 feet x 20 feet.)
2. Spray onto one place on pavement or dry ground. Note width of spray pattern. Double spraying is desirable to increase uniformity of application; if the sprayer covered an area 6 feet wide, moving each swath over 3 feet provides double spraying.
3. Set stakes, rocks, or other markers at this interval along 2 opposite sides of the measured 1,000 square feet.
4. Fill container with water to a mark near the top.
5. Spray the marked-off 1,000 square feet. Kick down stakes as each swath is covered.
6. Measure the amount of water needed to fill to original level. This volume is crucial to the calibration.
7. Mix the amount of the pesticide to be applied per 1,000 square feet in the amount of total mixture applied from the container. For example, if 6 fluid ounces of liquid were applied from the sprayer reservoir to the 1,000 feet and you want to apply 0.75 fluid ounces of pesticide -then you would mix 0.75 ounces of pesticide with 5.25 ounces of water to make 6 fluid ounces of spray solution in the sprayer reservoir.
8. Apply this mixture with similar water pressure, speed, and swath width as calculated.

Compiled by Herbert Cole, Jr., Professor, Plant Pathology

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III. CALCULATION METHODS AND CONVERSIONS FOR PESTICIDE APPLICATION

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USEFUL CALCULATION METHODS TO DETERMINE VARIOUS APPLICATION CRITERIA

1. To determine the amount of active ingredient needed to mix in the spray tank:

$$\begin{array}{l} \text{Number of gallons or pounds} \quad \text{pounds active ingredient} \\ = \frac{\text{number of acres to be sprayed} \times \text{required per acre}}{\text{pounds active ingredient per gallon or per pound}} \end{array}$$

2. To determine the amount of pesticide needed to mix a spray containing a certain percentage of the active ingredient:

$$\begin{array}{l} \text{Number of gallons or pounds} \\ = \frac{\text{gallons of spray desired} \times \% \text{ active ingredient wanted} \times 8.345^*}{\text{pounds active ingredient per gallon or per pound} \times 100} \end{array}$$

3. To determine the percent active ingredient in a spray mixture:
Percent

$$= \frac{\text{pounds or gallons of concentrate used (not just active ingredient)} \times \% \text{ active ingredient in the concentrate}}{\text{gallons of spray} \times 8.345}$$

4. To determine the amount of pesticide needed to mix a dust with a given percent active ingredient:

$$\begin{array}{l} \text{Pounds material} \\ = \frac{\% \text{ active ingredient wanted} \times \text{pounds mixed dust wanted}}{\% \text{ active ingredient in pesticide used}} \end{array}$$

5. To determine the size of pump needed to apply a given number of gallons per acre:

$$\begin{array}{l} \text{Pump capacity} \\ = \frac{\text{gallons per acre desired} \times \text{boom width (feet)} \times \text{mph}}{495} \end{array}$$

6. To determine the nozzle capacity in gallons per minute at a given rate per acre and miles per hour:

$$\begin{array}{l} \text{Nozzle capacity} \\ = \frac{\text{gallons per acre} \times \text{nozzle spacing (inches)} \times \text{mph}}{5940} \end{array}$$

7. To determine the acres per hours sprayed:

$$\begin{array}{l} \text{Acres per hour} \\ = \frac{\text{swath width (inches)} \times \text{mph}}{100} \end{array}$$

8. To determine the rate of speed in miles per hours:

First measure off a distance of 300 to 500 feet; then measure in seconds the time it takes the tractor to go the marked-off distance.

$$\text{mph} = \frac{.682 \times \text{distance}}{\text{seconds to travel distance}}$$

*8.345 is the weight in pounds of one gallon of water.

9. To determine the nozzle flow rate:
First note the time in seconds necessary to fill a pint jar from a nozzle.
Gallons per minute per nozzle = $\frac{7.5}{\text{seconds to fill jar}}$
10. To determine the gallons per minute per boom.
Calculate the gallons per minute per nozzle and multiply by the number of nozzles.
11. To determine the gallons per acre delivered:
Gallons per acre = $\frac{5940 \times \text{gallons per minute per nozzle}}{\text{nozzle spacing (inches)} \times \text{mph}}$
12. To determine the acreage sprayed per hour:
Acre sprayed per hour = $\frac{\text{boom width (feet)} \times \text{mph}}{12}$
(This allows 30% of the time for filling, turning, etc.)
13. Sprayer Tank Capacity
For cylindrical tanks:
Number of gallons = length in inches x diameter squared x .0034
For elliptical tanks:
Number of gallons = length in inches x short diameter x long diameter x .0034
For rectangular tanks:
Number of gallons = length x width x depth x .004329
14. To determine the acres in a given area:
Number of acres = length in feet x width in feet x .000023
15. To calibrate a knapsack sprayer:
Spray a measured square rod area for one minute and catch the spray from the nozzle or nozzles.
Gallons per acre = 20 x pints caught in one minute

AREA AND VOLUME CONVERSIONS

LINEAR MEASURE

1 foot = 12 inches
1 yard = 3 feet
1 rod = 5.5 yards = 16.5 feet
1 mile = 160 rods = 1760 yards = 5280 feet

SQUARE MEASURE

1 square foot = 144 square inches
1 square yard = 9 square feet
1 square rod = 272.25 square feet = 30.25 square yards
1 acre = 43,560 square feet = 4840 square yards = 160 square rods
1 square mile = 640 acres
1 acre = 209 square feet

CUBIC MEASURE

1 cubic foot = 1728 cubic inches = 29.922 quarts = 7.48 gallons
1 cubic yard = 27 cubic feet
1 cubic foot of water = 62.5 pounds

LIQUID CAPACITY MEASURE

1 tablespoon = 3 teaspoons
1 fluid ounce = 2 tablespoons
1 cup = 8 fluid ounces
1 pint = 2 cups = 16 fluid ounces
1 quart = 2 pints = 32 fluid ounces
1 gallon = 4 quarts = 8 pints = 128 fluid ounces

WEIGHT MEASURE

1 pound = 16 ounces
1 hundredweight = 100 pounds
1 ton = 2000 pounds = 20 hundredweight

METRIC MEASURE

1 gram = .035 ounce
1 kilogram = 2.2 lb
1 quintal = 100 kg = 221 lb
1 metric ton = 1000 kg = 2,205 lb
1 hectare = 2.5 acres
1 meter = 39.4 inches
1 kilometer = .6 mile

TEMPERATURE CONVERSIONS

2

IMPORTANT CONVERSION FORMULAE

volume of a sphere = diameter³ x .5236
diameter = circumference x .31831
area of a circle = diameter² x .7854
area of an ellipse = wide diameter x narrow diameter x .7854
volume of a cone = area of base x height
3

pressure in pounds
per square inch = height in feet x .434
parts per million = percentage x 10,000
percentage = $\frac{\text{parts per million}}{10,000}$

The formula for conversion from Centigrade to Fahrenheit is:

$$^{\circ}\text{F} = \frac{(^{\circ}\text{C} \times 9)}{5} + 32 \quad \text{or} \quad ^{\circ}\text{F} = (^{\circ}\text{C} \times 1.8) + 32$$

The formula for conversion from Fahrenheit to Centigrade is:

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times \frac{5}{9} \quad \text{or} \quad ^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times 0.5556$$

CONVERSION FACTORS

<u>To Convert from</u>	<u>To</u>	<u>Multiply by</u>
cubic feet	gallons	7.48
cubic feet	liters	28.3
gallons	milliliters	3785
grams	pounds	.0022
grams/liter	parts/million	1000
grams/liter	pounds/gallon	.00834
liters	cubic feet	.0353
milligrams/liter	parts/million	1.0
milliliters	gallons	.0026
ounces	grams	28.35
parts/million	grams/liter	.001
parts/million	pounds/million gallons	8.34
pounds	grams	453.59
pounds/gallon	grams/liter	111.83

CONVERSIONS FOR RATES OF APPLICATION

1 ounce per square foot	= 2722.5 pounds per acre
1 ounce per square yard	= 302.5 pounds per acre
1 ounce per 100 square feet	= 27.2 pounds per acre
1 pound per 100 square feet	= 435.6 pounds per acre
1 pound per 1000 square feet	= 43.6 pounds per acre
1 gallon per acre	= 1/3 ounce per 1000 square feet
5 gallons per acre	= 1 pint per 1000 square feet
100 gallons per acre	= 2.5 gallons per 1000 square feet
	= 1 quart per 100 square feet
100 pounds per acre	= 2.5 pounds per 1000 square feet

APPLICATION RATES OF ACTIVE INGREDIENT PER ACRE
FOR VARIOUS CONCENTRATIONS OF EMULSIFIABLES, WETTABLES, AND DUSTS

Pounds of active chemical recommended per acre:

1/8 1/4 1/2 3/4 1 1 1/2 2 2 1/2 3 5

Amount of formulation needed to obtain the above amounts of active chemical for:

10%-12% Emulsion Concentrate (contains 1 pound chemical per gallon)

1	1	2	3	1	1 1/2	2	2 1/2	3	5
pt	qt	qt	qt	gal	gal	gal	gal	gal	gal

15%-20% Emulsion Concentrate (contains 1 1/4 pounds chemical per gallon)

1/3	2/3	1 1/3	2	2 2/3	1	1 1/3	1 2/3	2	3 2/5
qt	qt	qt	qt	qt	gal	gal	gal	gal	gal

25% Emulsion Concentrate (contains 2 pounds chemical per gallon)

1/2	1	1	3	2	3	1	5	1 1/2	2 1/2
pt	pt	qt	pt	qt	qt	gal	qt	gal	gal

40%-50% Emulsion Concentrate (contains 4 pounds chemical per gallon)

1/4	1/2	1	1 1/2	1	3	2	5	3	5
pt	pt	pt	pt	qt	pt	qt	pt	qt	qt

60%-65% Emulsion Concentrate (contains 6 pounds chemical per gallon)

1/6	1/3	2/3	1	1 1/3	1	2 2/3	3 1/3	2	3 1/3
pt	pt	pt	pt	pt	qt	pt	pt	qt	qt

70%-75% Emulsion Concentrate (contains 8 pounds chemical per gallon)

1/8	1/4	1/2	3/4	1	1 1/2	1	2 1/2	3	2 1/2
pt	pt	pt	pt	pt	pt	qt	pt	pt	qt

15% Wettable Powder

3/4	1 1/2	3 1/3	5	6 2/3	10	13 1/2	16 2/3	20	33 1/3
lb	lb	lb	lb	lb	lb	lb	lb	lb	lb

25% Wettable Powder

1/2	1	2	3	4	6	8	10	12	20
lb	lb	lb	lb	lb	lb	lb	lb	lb	lb

40% Wettable Powder

5	10	1 1/4	1 7/8	2 1/2	3 3/4	5	6 1/4	7 1/2	12 1/2
oz	oz	lb	lb	lb	lb	lb	lb	lb	lb

50% Wettable Powder

1/4	1/2	1	1 1/2	2	3	4	5	6	10
lb	lb	lb	lb	lb	lb	lb	lb	lb	lb

75% Wettable Powder

1/6	1/3	2/3	1	1 1/3	2	2 2/3	3 1/3	4	6 2/3
lb	lb	lb	lb	lb	lb	lb	lb	lb	lb

80% Wettable Powder

2 1/2	5	5/8	15/16	1 1/4	1 7/8	2 1/2	3 1/8	3 3/4	6 1/4
oz	oz	lb	lb	lb	lb	lb	lb	lb	lb

1% Dust

12 1/2	25	50	75	100	150	200	250	300	500
lb	lb	lb	lb	lb	lb	lb	lb	lb	lb

5% Dust

2 1/2	5	10	15	20	30	40	50	60	100
lb	lb	lb	lb	lb	lb	lb	lb	lb	lb

10% Dust

1 1/4	2 1/2	5	7 1/2	10	15	20	25	30	50
lb	lb	lb	lb	lb	lb	lb	lb	lb	lb

QUANTITIES OF PESTICIDE NECESSARY TO ACHIEVE
THE SAME CONCENTRATION IN VARIOUS QUANTITIES OF WATER

WATER	PESTICIDE					
	Powder					
100 gal	1 lb	2 lb	3 lb	4 lb	5 lb	
50 gal	.5 lb	1 lb	1.5 lb	2 lb	2.5 lb	
12 1/2 gal	4 oz	8 oz	12 oz	1 lb	1.25 lb	
6 1/4 gal	2 oz	4 oz	6 oz	8 oz	10 oz	
3 1/8 gal	1 oz	2 oz	3 oz	4 oz	5 oz	
1 gal	4.5 g	9.1 g	13.6 g	18.1 g	22.7 g	
1 liter	1.2 g	2.4 g	3.6 g	4.8 g	6.0 g	
1 qt	1.1 g	2.3 g	3.4 g	4.5 g	5.7 g	

WATER	PESTICIDE					
	Liquid					
100 gal	.5 pt	1 pt	1 qt	2 qt	1 gal	
50 gal	.25 pt	.5 pt	1 pt	1 qt	2 qt	
25 gal	2 oz	4 oz	8 oz	1 pt	1 qt	
12 1/2 gal	1 oz	2 oz	4 oz	8 oz	1 pt	
6 1/4 gal	.5 oz	1 oz	2 oz	4 oz	8 oz	
3 1/8 gal	.25 oz	.5 oz	1 oz	2 oz	4 oz	
1 gal	.75 oz	1.5 oz	3 oz	6.25 oz	12.5 oz	
1 liter	0.625 ml	1.25 ml	2.5 ml	5.0 ml	10.0 ml	
1 qt	.2 oz	4 oz	8 oz	1.5 oz	3.2 oz	

* fluid oz

CONCENTRATIONS OF CHEMICALS IN SOIL

Amount of Chemical Required to Give Indicated Concentration in Soil*

Parts per Million Concentration in Soil	1 Square Foot To Soil Depth Of:			1000 Square Feet To Soil Depth Of:			1 Acre (43,560 sq ft) Soil Depth Of:		
	<u>1</u> <u>inch</u>	<u>4</u> <u>inches</u>	<u>12</u> <u>inches</u>	<u>1</u> <u>inch</u>	<u>4</u> <u>inches</u>	<u>12</u> <u>inches</u>	<u>1</u> <u>inch</u>	<u>4</u> <u>inches</u>	<u>12</u> <u>inches</u>
1	-	.01 g	.04 g	.11 oz	.43 oz	1.3 oz	0.3 lb	1.2 lb	3.5
10	-	0.1 g	0.4 g	1.1 oz	4.3 oz	13 oz	3 lb	12 lb	35 lb
50	0.2 g	0.7 g	2 g	5.4 oz	1.3 lb	4 lb	14 lb	58 lb	175 lb
100	0.38 g	1.3 g	4 g	10.8 oz	2.7 lb	8 lb	29 lb	117 lb	350 lb
150	0.5 g	2.0 g	6 g	1.0 lb	4 lb	12 lb	44 lb	175 lb	525 lb
200	0.8 g	2.6 g	8 g	1.3 lb	5.3 lb	16 lb	58 lb	233 lb	700 lb
500	1.7 g	6.7 g	20 g	3.3 lb	13.3 lb	40 lb	146 lb	583 lb	1750 lb
1000	3.4 g	13.4 g	40 g	6.7 lb	26.7 lb	80 lb	292 lb	1167 lb	3500 lb

* Assumes soil specific gravity of 1.3, equivalent to 81 pounds of dry soil per cubic foot.
Modify amounts of chemical proportionately for higher or lower specific soil gravity.

SPRAY CONCENTRATION CONVERSIONS

<u>Ounces</u> <u>Per 100 Gallons</u>	<u>Parts</u> <u>per Million</u>	<u>Percent</u> <u>Solution</u>	<u>Grams per 100 liters</u>
2/3	50	.005	5
1	75	.0075	7.5
1 1/3	100	.01	10
2	150	.015	15
2 2/3	200	.02	20
3 1/3	250	.025	25
4	300	.03	30
5 1/3	400	.04	40
6 2/3	500	.05	50
8	600	.06	60
9 1/3	700	.07	70
10 2/3	800	.08	80
12	900	.09	90
13 1/3	1000	0.10	100
16	1200	0.12	120
20	1500	0.15	150
24	1800	0.18	180

PARTS PER MILLION RELATIONSHIPS

1 gram in 100 milliliters	=	10,000 ppm	=	1.0%
1 gram in 1 liter	=	1,000 ppm	=	0.1%
1 gram in 10 liters	=	100 ppm	=	0.01%
1 gram in 100 liters	=	10 ppm	=	0.001%
1 gram in 1000 liters	=	1 ppm	=	0.0001%
1 gram in 10,000 liters	=	0.1 ppm		

100 parts per million = 1.33 ounces per 100 gallons

OR

0.1 grams per liter

1 gram per 10 liters

10 grams per 100 liters

100 grams per 1000 liters

METRIC EQUIVALENTS

100 liters =	105.8 quarts	=	26.45 gallons
100 gallons =	378.5 liters		
1 ounce =	28.35 grams		
1 gram =	0.035 ounces		
10 grams =	0.35 ounces		
100 grams =	3.35 ounces		

CONVERSION TABLE FOR SMALL-AREA SPRAYING

Rate Per Acre	Rate Per 1,000 Square Feet	Rate Per 100 Square Feet	
1 lb	0.35 oz	0.25 tsp	Dry Materials
2	0.7	0.50 tsp	
3	1.1	0.75 tsp	
4	1.4	1.00 tsp	
5	1.8	1.25 tsp	
6	2.1	1.50 tsp	
8	2.8	1.75 tsp	
10	3.7	2.00 tsp	
20	7.3	0.73 oz	
40	14.0	1.4 oz	
50	18.0	1.8 oz	
100	37.0	3.7 oz	
200	73.0	7.3 oz	
300	110.0	11.0 oz	Liquid Materials
400	147.0	14.7 oz	
500	184.0	18.4 oz	
1 pt	0.36 fl oz	0.25 tsp	
1 qt	0.72 fl oz	0.50 tsp	
1 gal	2.9 fl oz	2.00 tsp	
2 gal	5.9 fl oz	4.00 tsp	
3 gal	8.8 fl oz	2.00 Tbsp	
5 gal	14.7 fl oz	3.00 Tbsp	
10 gal	29.4 fl oz	6.00 Tbsp	
15 gal	2.8 pt	9.00 Tbsp	
20 gal	3.7 pt	12.00 Tbsp	
25 gal	2.3 qt	15.00 Tbsp	
50 gal	4.6 qt	1.84 cups	
75 gal	6.9 qt	2.76 cups	
100 gal	9.19 qt	3.67 cups	
200 gal	18.37 qt	7.35 cups	

Dry: 1 lb/100 gal = 1 oz/6 1/4 gal = 1/2 oz/3 gal = 4.5 gm/gal
 Liquid: 1 pt/100 gal = 1 fl oz/6 1/4 gal = 1/2 fl oz/3 gal = 1 tsp/gal
 1 qt/100 gal = 10 tsp/5 gal = 2 Tbsp/3 gal = 2 tsp/gal
 1 gal/100 gal = 3/4 cup + 4 tsp/5 gal = 1/2 cup/3 gal = 8 tsp/gal

QUANTITIES OF PESTICIDE IN LIQUID FORMULATION
 FOR EQUIVALENCE BETWEEN 100 GALLONS AND 1 GALLON

Pounds of Active Chemical
 Per Gallon of Concentration

Teaspoons per Gallon
 To Equal 1 Pound per 100 Gallons
 Of Dilute Spray

1	8
2	4
3	3
4	2
6	1 1/2
8	1

TRACTOR SPEED CONVERSIONS

<u>Miles per Hour</u>	<u>Feet per Minute</u>	<u>Time required in seconds to travel</u>		
		<u>100 feet</u>	<u>200 feet</u>	<u>300 feet</u>
1	88	68	137	205
1.5	132	45	91	136
2	176	34	68	102
2.5	220	27	54	81
3	264	23	46	68
4	352	17	34	51
5	440	13.6	27	41
6	528	11.3	23	34
7	618	9.7	20	29
8	704	8.5	17	27

ACRES SPRAYED PER TANKFUL

<u>allons per Acre</u>	<u>Tank Capacity</u>									
	30	50	55	60	75	100	110	150	200	500
5	6.0	10.0	11.0	12.0	15.0	20.0	22.0	30.0	40.0	100.0
6	5.0	8.3	9.2	10.0	12.5	16.7	18.3	25.0	33.3	83.3
7	4.3	7.1	7.9	8.6	10.7	14.3	15.7	21.4	28.6	71.4
8	3.8	6.3	6.9	7.5	9.4	12.5	13.7	18.8	25.0	62.5
9	3.3	5.6	6.1	6.7	8.3	11.1	12.2	16.7	22.2	55.6
10	3.0	5.0	5.5	6.0	7.5	10.0	11.0	15.0	20.0	50.0
15	2.0	3.3	3.7	4.0	5.0	6.7	7.3	10.0	13.3	33.3
20	1.5	2.5	2.8	3.0	3.8	5.0	5.5	7.5	10.0	25.0

CONVERTING WIDTH OF AREA COVERED TO ACRES TRAVELED PER MILE

<u>Width of Strip (feet)</u>	<u>Acres per Mile</u>
6	.72
10	1.21
12	1.45
16	1.93
18	2.18
20	2.42
25	3.02
30	3.63
50	6.04
75	9.06
100	12.1
150	18.14
200	24.2
300	36.3

TRACTOR SPEED AND SPRAY RATES

$$\text{Tractor Speed} = \frac{\text{gallons per minute} \times 495}{\text{gallons per acre} \times \text{width of spray}}$$

$$\text{Gallons Per Acre} = \frac{\text{gallons per minute} \times 495}{\text{miles per hour} \times \text{width of spray}}$$

$$\text{Tractor Speed} = \frac{0.682 \times \text{distance}}{\text{seconds}}$$

$$\text{Gallons Per Minute} = \frac{\text{gallons per acre} \times \text{miles per hour} \times \text{nozzle spraying in inches}}{5,940}$$

CALIBRATION OF NOZZLE FLOW RATES

<u>Gallons per Minute</u>	<u>Seconds for 1 pint</u>	<u>Gallons per Minute</u>	<u>Seconds for 1 quart</u>
.05	150	.175	20
.06	125	.20	75
.07	107	.225	67
.08	94	.25	60
.09	84	.30	50
.10	75	.325	46
.11	68	.35	43
.12	62	.40	38
.13	58	.425	35
.14	53	.45	33
.15	50	.50	30

Compiled by Herbert Cole, Jr., Professor, Plant Pathology

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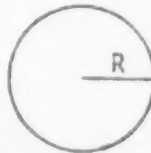
AREA MEASUREMENTS

Calibration of equipment depends on your ability to measure the area to be treated. If the area is a rectangle, circle, or triangle, simple formulas may be used.

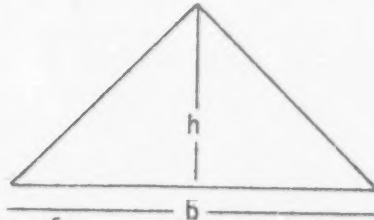
Rectangles: The area of a rectangle is found by multiplying the length by the width. $\text{Area} = \text{length} \times \text{width}$



Circles: The area of a circle is the radius (one-half the diameter) squared and then multiplied by 3.14. $\text{Area} = 3.14 \times \text{radius squared}$

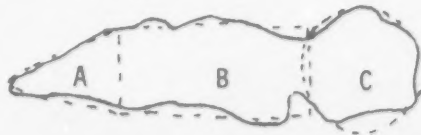


Triangles: The area of a triangle is one-half the base multiplied by the height. $\text{Area} = \frac{b \times h}{2}$



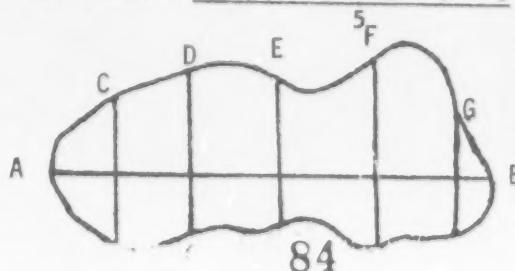
Irregularly shaped areas often can be reduced to one or more of these common shapes. Calculate the area of each and add them together to obtain the total area.

Example: $\text{Area A} + \text{B} + \text{C} = \text{Total Area}$



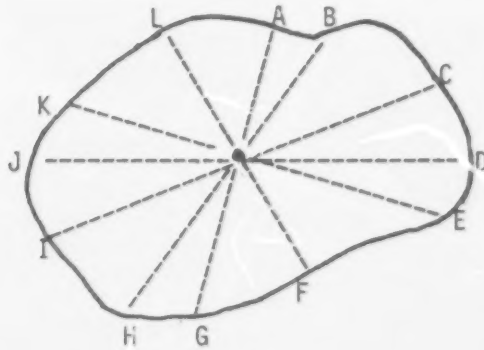
Another way is to establish a line down the middle of the property for the length, and then measure from side to side at several points along this line. Areas with very irregular shape require more side to side measurements. The average of the side measurements can be used as the width. The area is then calculated as a rectangle. ($\text{Area} = \text{length} \times \text{width}$)

Example: $\text{Length} = \text{line AB}; \text{Width} = \frac{\text{line C} + \text{D} + \text{E} + \text{F} + \text{G}}{5}$



A third method is to convert the area into a circle. From a center point, measure distance to the edge of the area in 10 to 20 increments. Average these measurements to find the average radius. Then calculate the area using the formula for a circle. (Area = $3.14 \times \text{radius squared}$)

Example: $(3.14) \times \frac{\text{line A} + \text{B} + \text{C} + \text{D} + \text{E} + \text{F} + \text{G} + \text{H} + \text{I} + \text{J} + \text{K} + \text{L}}{12} = \text{Area}$



Section 4

FACT SHEETS

PLEASE NOTE

If you desire up-to-date fact sheets on control of weeds in ornamentals and turf, please contact your County Agent. Ask for:

1. 1977 New England Chemical Weed Control for Turfgrass
2. 1977 New England Control of Weeds in Nursery Crops
3. 1977 New England Brush Control in non-food Crop Areas and
Weed and Brush Control in Christmas Tree Stands



MOLES

Prepared by H. Stevan Logsdon, Extension Wildlife Specialist and Craig R. Fox

Cooperative Extension Service, University of New Hampshire, in cooperation with the Institute of Natural and Environmental Resources, Pettee Hall, Durham, N.H. 03824, Tel. (603) 862-1000

Two species of moles are found in New Hampshire. Star-nosed Moles (*Condylura cristata*) frequent damp soils near swamps, streams and lake edges. Hairy-tailed Moles (*Parascalops breweri*) prefer well-drained upland soils. Both are common throughout the State.

Moles are small, mouse-sized mammals adapted to living underground. They are characterized by enlarged forefeet with long claws, stout necks and powerful shoulders which make them capable burrowers. Unlike those of mice and shrews, the noses and forefeet of moles are pink and hairless.

Hairy-tailed Moles have slate-colored fur while Star-nosed Moles are normally dark brown or black. Both moles have hair-covered tails. However, Star-nosed Moles have longer tails and the numerous fleshy nose projections for which this mole was named. Moles generally range from five to seven inches in length.

Special sensory hairs on the noses and forefeet of moles enable them to find food in a subterranean environment where other senses are not as useful. The eyes of moles are almost entirely covered by skin and their ears are hidden. Although moles do not appear to sense light with their eyes, their ears may be used to hunt and to evade predators. Some sources attribute the successful establishment of moles underground to the increased development of senses which can detect changes in air pressure, temperature and movement.

Habits

Moles burrow by forcing their enlarged forefeet into the soil and pushing backward and to the side. The mole's velvety fur may be brushed in any direction without resistance. This enables the animal to move backwards or forwards with a decreased expenditure of energy and increases its food-securing ability. Within a 24-hour period a mole may consume the equivalent of one-half its

body weight. Moles feed during the day and night, generally stopping for three resting periods. Earthworms and soil invertebrates, such as the larval or grub forms of insects, constitute the largest portion of their diet. Moles also feed on spiders, snails, small vertebrates and eat small amounts of bulbous or fleshy-rooted vegetation. Moles have been observed to feed on the carcasses of buried animals. The Star-nosed Mole, which frequently enters water, may consume aquatic insects and small fish.

Although moles prefer loose, sandy-loam soils, they have been observed to occupy a variety of habitats and soil types. Requirements for moles include adequate soil moisture and depth. The amounts of vegetation and organic matter present affects the abundance of soil animals upon which moles feed. Moles normally avoid dry, clay or highly-acidic soils because such soils contain a scarce supply of food and are difficult to burrow through. Conversely, moles will move into an area where food is abundant and soil conditions are optimal.

Two types of burrows are made by moles. Surface tunnels are created as moles move through the soil in search of food. Deeper passages are dug joining the nesting cavity to an elaborate system of burrows. The passages are marked by piles of excavated earth on the ground surface. The maze of burrows surrounding the nesting chamber increases the likelihood of escape from predators and may serve to aerate the moles' nests. Large numbers of surface tunnels are dug to insure a sufficient supply of food as moles depend on earthworms and insects which enter or fall into their runways for most of their diet. Moles form hardened chambers where they store large numbers of earthworms. Occasionally moles leave their burrows to feed above ground and to collect grasses and leaves for the nesting cavity.

Moles are strongly territorial and will defend their burrows against intrusion by others. Most burrow systems are separate, with only one male or female using the complex. Where contacts are made, fighting often occurs



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which may end in death. This serves to limit mole populations, which in turn, insures enough food for the occupants of individual territories. Contacts between moles occur infrequently except during the late winter (February to April) when they breed. During the breeding season male moles dig straight tunnels to intersect the territories of females. After mating, moles re-inhabit separate burrow systems. Gestation lasts for four to six weeks after which two to five (usually four) young are born. The young grow rapidly and leave the nest after four weeks to forage for themselves. Young moles which do not find abandoned burrows often live at the surface for brief periods of time before deeper burrows are made. Raised burrows are often observed after the spring snow melt.

The average lifespan of most moles is from two to three years. Because Hairy-tailed and Star-nosed Moles venture to the ground surface where they are exposed to increased predation, their lifespans are usually much shorter. Animals which commonly prey on moles include hawks, owls, herons, foxes, skunks, weasels and snakes.

Identification

Moles become nuisances where their surface tunneling or burrow excavations extend into lawns, golf courses and gardens. Because of the burrowing ability of moles, numerous runways and piles of dirt may appear in a relatively short period of time. Where mole numbers are few and tunneling is minimal, they will normally not cause serious damage.

Grass, flower beds, vegetable gardens and shrubs may be indirectly damaged by the physical disturbance of plant roots which are in proximity to mole tunnels. Moles occasionally feed on the roots of plants. Gnawed or girdled trees and shrubs or chewed vegetables are usually the work of meadow mice which often use the surface tunnels of moles for runways. Although moles occasionally damage plants, their activities are beneficial since they aerate and mix the soil. Their burrowing increases the availability of water to plant roots and the numbers of unwanted insects may be reduced.

Mole activity is normally obvious. Continuous ridges of raised earth and small mounds of dirt will be observed where moles have burrowed. Star-nosed Moles are rarely nuisances because they prefer wetter habitats.

Control Methods

Moles are usually difficult to control. Limited populations of moles may be satisfactorily reduced by trapping with the "harpoon" or "prong" type trap. Traps are available through farm and garden supply or hardware stores. Directions are supplied by the manufacturers.

Successful trapping involves the identification of actively-used tunnels and an understanding of mole activities. Runways which are not abandoned and are being used as moles feed and travel may be identified by depressing short sections of the raised ridges. Depressed sections should be marked with flagging and checked for repairs. Tunnels which have not been repaired are abandoned and should not be used for trapping. Set traps only at active locations and move them to other active sites within two to three days if no moles are caught.

Moies entering a garden may be deterred by sinking one-quarter-inch wire mesh fencing 1½ to two feet into the ground, allowing at least one foot of mesh above ground. Where mounds of earth are present in the garden, trapping may be necessary to remove moles before the garden is enclosed.

In cases where mole populations are unusually dense, their food supply may be reduced. A reduction of soil insects and earthworms with the use of insecticides may cause moles to starve or to seek other food sources nearby. *Careful consideration should be given to the detrimental effects of insecticide use.* Insecticides are highly toxic and may be harmful to people, pets and other forms of wildlife such as birds which eat toxic earthworms. Elimination of soil organisms which aerate and mix lawn or garden soils may do more damage to vegetation than digging by moles. Because soil organisms limit fungus growth in soils, a reduction of these organisms may result in the spread of lawn or crop-damaging fungi. Fungus growth can result in large patches of brown and dying grass. Before insecticides are used current information on chemical controls should be obtained from the county Cooperative Extension Service office. The addition of fertilizers or humus to lawns will increase the numbers of earthworms and insects present, creating a habitat which may attract moles.

Gassing is normally ineffective because of the moles' extensive burrow system and its numerous openings. Repellents have not been successful and the use of poisonous baits is currently illegal.

Ecological Significance

Although moles become nuisances, their presence in woodlands or overgrown fields is seldom noticed. They aerate and loosen the soil which improves conditions for vegetative growth. Because moles require large amounts of food, they act to limit some species of insects while providing an important food source for a number of predators. A reduction in numbers may be more desirable than complete elimination.

We would like to acknowledge the assistance of Rene Bollengier and John Davis of the New Hampshire Fish and Game Department in the preparation of this pamphlet.

Additional Sources of Information

Burt, H. W. and Grossenheider, R. P. 1964. *A Field Guide to the Mammals*. Houghton Mifflin Co., Boston, 272 pp.

Mellanby, Kenneth. 1971. *The Mole*. Taplinger Publ. Co., N.Y., 159 pp.

New Hampshire Department of Fish and Game, 34 Bridge Street, Concord, New Hampshire 03301. Tel. (603) 271-3421.

U.S. Fish and Wildlife Service, 55 Pleasant Street, Concord, New Hampshire 03301. Tel. (603) 225-9621.

COOPERATIVE EXTENSION SERVICE

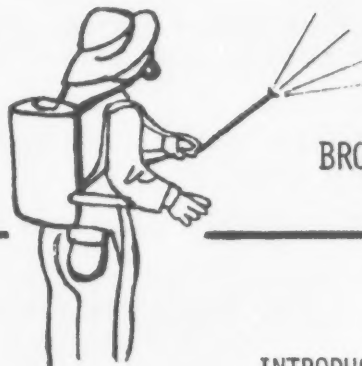
University of New Hampshire

Pest Fact Sheet

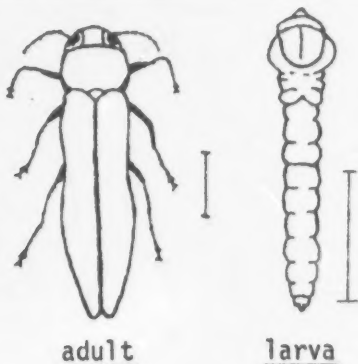
No. 12

PESTICIDE APPLICATOR TRAINING

GREENHOUSE AND NURSERY



BRONZE BIRCH BORER



adult

larva

INTRODUCTION

The Bronze Birch Borer, Agrilus anxius Gory, is found throughout the birch range in the U.S. and Canada. It attacks and breeds in Paper Birch, Yellow Birch, Gray Birch, Western Paper Birch, Water Birch, Sweet Birch, and it has been found in stands of beech and aspen. Paper and Yellow Birch are the preferred hosts.

DESCRIPTION OF THE BRONZE BIRCH BORER

The larvae of the Bronze Birch Borer are slender, flattened, and have two small spines at the end of the abdomen. They are about 25 mm long.

The adults are a deep olive green to bronze in color. The segment behind the head is a copper color and the head is greenish in males and copper in females. They range from 3/8 to 1/2" in length.

LIFE CYCLE

In N.H., it takes two years for the Bronze Birch Borer to complete development. Adults begin to emerge in late May and early June and can be found emerging until August. After emerging, the adults feed on the leaves for about three weeks. After feeding, they mate and the female deposits her eggs singly or in groups in cracks and crevices in the bark usually on the unshaded areas of the tree. Upon hatching, in two weeks, the larvae bore through the bark and into the wood forming galleries where they will overwinter. It is believed that only fully developed larvae can withstand the winter temperatures and survive the winter. In the following spring, the larvae pupate and the adults emerge.

Larval feeding interferes with sap movement within the tree. If the bark is removed, oblong galleries can be found. Bronze Birch Borers usually attack weakened trees and trees that are vigorous usually ward off any borer attack.

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CONTROL

The best means of control is prevention. Proper maintenance of a birch stand by fertilization, pruning, and watering will keep a birch stand vigorous and is the best line of defense.

If necessary, two foliage applications, seven days apart, of carbaryl (Sevin) may be used mid-May, early June.

A trunk application of lindane* seven days after the last carbaryl application is also recommended.

If the use of carbaryl was omitted in June, apply a foliar application of lindane* in July.

* Restricted use pesticide in N.H.

SUMMARY

- | | |
|-------------------------------------|------------------------------------|
| 1. Damaging Stage: | Adult--Foliage
Larva--Woodborer |
| 2. Part of Plant Attacked: | Leaves, Sapwood |
| 3. Overwintering Stage: | Fully-Developed Larva |
| 4. Number of Generations Per Year: | One every <u>Two</u> Years |
| 5. Time of Year When Damage Done: | May, June, July |
| 6. Number of Applications Per Year: | 1-3 |

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed. Avoid inhaling dusts or sprays. Open windows and ventilate the rooms while using pesticides. Never smoke or eat while spraying or dusting. Remove or cover food, feed, water, kitchen utensils and fish and other pets. Do not allow children near you when applying pesticides. Wash and clean up after using pesticides - change clothes if any pesticide was spilled. Dispose of empty containers safely. Bury 18" deep in an isolated area away from any water supply or place in a trash container. Do not burn aerosol cans. Store pesticides in their original containers in a locked cabinet or shed away from food. Be sure tops or caps are on tight. In case of an accident, follow label directions and call a physician immediately.

James S. Bowman
Jon P. Turmel
Extension Entomologists

COOPERATIVE EXTENSION SERVICE

University of New Hampshire

Pest Fact Sheet

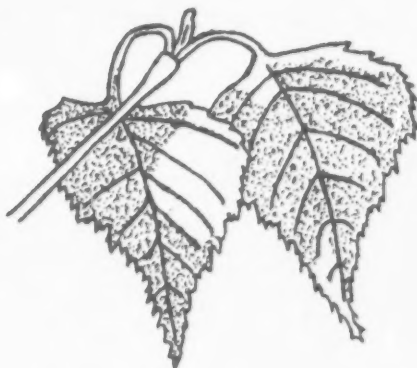
No. 13

PESTICIDE APPLICATOR TRAINING

GREENHOUSE AND NURSERY



BIRCH LEAF MINER



INTRODUCTION

Gray Birch, Paper Birch, and European White Birch are among the favorite host plants of the Birch Leaf Miner, Fenusa pusilla Lepeletier. This European native was introduced into the U.S. pre-1923 and has grown to economic levels as one of the most important nursery insect pests of N.H.

DESCRIPTION OF THE BIRCH LEAF MINER

In its damaging stage, the larva of the Birch Leaf Miner is a translucent white color, is somewhat flattened, and is 6 mm in length. Several black spots can be found on the underside of the thorax, which is the part of the body where the legs are attached. A black spot is also found on the 1st segment of the abdomen.

The adults are small black wasp-like insects about 1/8" long.



LIFE CYCLE

Buried 1-2" deep, the Birch Leaf Miner overwinters as a full grown larva encircled by a cocoon in the soil. In mid to late May, the larva pupates, and under proper weather conditions, the adults emerge in 8-15 days. After mating, the female, capable of laying several hundred eggs, lays her eggs in the developing birch leaves. In six to ten days, the eggs hatch, (1-20 per leaf) and the young begin to mine between the lower and upper surfaces of the leaf.

This feeding will eventually cause larger blotches in the leaves, a wilting of the leaves, and gradual leaf death. It takes away from the photosynthetic abilities of the tree itself. In most areas, this feeding weakens the tree and causes the birch to be less vigorous and more susceptible to invasion by other insects and diseases. Sometimes the damage from the Birch Leaf Miner can be fatal to the life of the tree.

There are 2 generations of the Birch Leaf Miner per year in N.H.

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CONTROL

The Birch Leaf Miner is controlled by either a single application of granular systemic insecticide in the spring after the buds break, or by two foliar sprays, one in mid-late May and one in early July, to kill the larvae in their mines. Follow label directions for proper application methods and precautionary measures.

Systemic Insecticides: Apply after buds break during April and early May.

1. disulfoton (Di-Syston)* 15G
2. aldicarb (Temik)* 15G (For use on commercial field grown and nursery plantings)

Sprays: Apply in mid-late May and early July.

1. carbaryl (Sevin) WP
2. malathion WP or EC
3. dimethoate (Cygon or Daphene) EC
4. Meta-Systox-R*

* Restricted use pesticide in N.H.

SUMMARY

- | | |
|------------------------------------|---------------------------------------|
| 1. Damaging Stage: | Larva |
| 2. Part of Plant Attacked: | Birch Leaves |
| 3. Overwintering Stage: | Fully Grown Larva in a Cocoon in Soil |
| 4. Number of Generations Per Year: | 2 |
| 5. Time of Year when Damage Done: | May, July |
| 6. Number of Applications Used: | 1-2 |

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed. Avoid inhaling dusts or sprays. Open windows and ventilate the rooms while using pesticides. Never smoke or eat while spraying or dusting. Remove or cover food, feed, water, kitchen utensils and fish and other pets. Do not allow children near you when applying pesticides. Wash and clean up after using pesticides - change clothes if any pesticide was spilled. Dispose of empty containers safely. Bury 18" deep in an isolated area away from any water supply or place in a trash container. Do not burn aerosol cans. Store pesticides in their original containers in a locked cabinet or shed away from food. Be sure tops or caps are on tight. In case of an accident, follow label directions and call a physician immediately.

James S. Bowman
Jon P. Turmel

Extension Entomologists

COOPERATIVE EXTENSION SERVICE

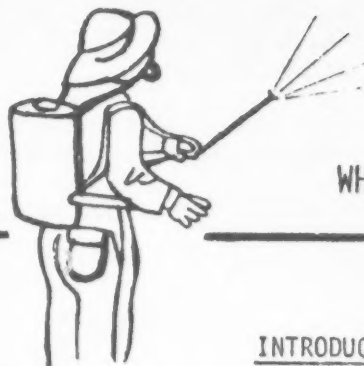
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Pest Fact Sheet

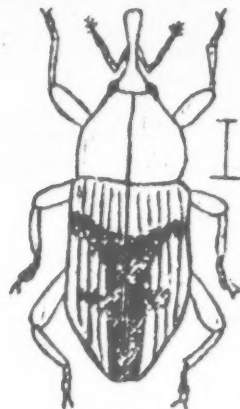
No. 14

PESTICIDE APPLICATOR TRAINING

GREENHOUSE AND NURSERY



WHITE PINE WEEVIL



adult



larva

INTRODUCTION

The White Pine Weevil is the most destructive insect pest of eastern white pine in North America. Norway spruce, jack pine, Scotch pine, pitch pine, red pine, blue spruce, and white spruce are also susceptible to White Pine Weevil damage. Damage from this weevil results in reduction of lumber yield for lumbermen and poor quality ornamentals for nurserymen.

DESCRIPTION OF THE WHITE PINE WEEVIL

Larvae of the White Pine Weevil are slightly larger than the adult (5-7 mm), are yellowish-white in color, and are legless.

The adult is a snout beetle about 4-6 mm in length. The wing covers (elytra) are marked with brown and white scales with a white patch of these scales at the tip of these wing covers.

The resting stage is a creamy-white pupa and is the same length as the adult (4-6 mm).

LIFE CYCLE

The adult White Pine Weevil overwinters in litter on the ground. From April to May, they emerge and begin to feed on the terminal growth. They favor feeding on the bark 7-10" below the dormant terminal buds.

Eggs are then deposited in the bark of the terminal and hatch in 7-10 days.

The developing larva feeds on the inner bark until maturity in July. Pupation occurs in the larval chambers and the adult then emerges in 10-15 days and continues to feed on old and new growth. The adult feeding does as much damage as the larval feeding.

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CONTROL

At the first sign of wilting and drooping of terminals, check for excessive pitch flow. This usually occurs in late spring. If excessive pitch flow is found, cut open the area of pitch exit and look for the larvae. If found, remove the entire leader and destroy it by burning.

For control of the adult, spray the terminals with Lindane* in early April, or with Meta-Systox-R* (0.5%) in late April or early May.

Make sure to check all labels for proper application and rates.

* Restricted use pesticide in N.H.

SUMMARY

- | | |
|-------------------------------------|-------------------------------|
| 1. Damaging Stage: | Adult and Larva |
| 2. Part of Plant Attacked: | Terminal Leader |
| 3. Overwintering Stage: | Adult |
| 4. Number of Generations Per Year: | 1 |
| 5. Time of Year When Damage Done: | April - May (Adult and Larva) |
| 6. Number of Applications Per Year: | 1 |

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed. Avoid inhaling dusts or sprays. Open windows and ventilate the rooms while using pesticides. Never smoke or eat while spraying or dusting. Remove or cover food, feed, water, kitchen utensils and fish and other pets. Do not allow children near you when applying pesticides. Wash and clean up after using pesticides - change clothes if pesticide was spilled. Dispose of empty containers safely. Bury 18" deep in an isolated area away from any water supply or place in a trash container. Do not burn aerosol cans. Store pesticides in their original containers in a locked cabinet or shed away from food. Be sure tops or caps are on tight. In case of an accident, follow label directions and call a physician immediately.

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1/76/1.5M

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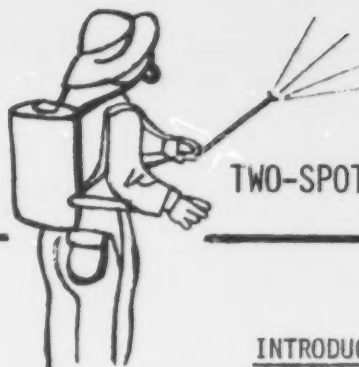
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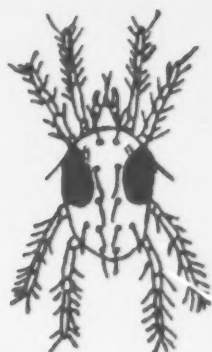
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PESTICIDE APPLICATOR TRAINING

GREENHOUSE AND NURSERY



TWO-SPOTTED SPIDER MITE



INTRODUCTION

There are several species of spider mites that invade field, garden, greenhouse, nursery, and ornamental plants. The most troublesome of these spider mites is the Two-Spotted Spider Mite, Tetranychus urticae Koch. This mite removes the sap from the leaf tissue, leaving the leaf speckled and when severely infested, the entire plant may die.

DESCRIPTION OF THE TWO-SPOTTED SPIDER MITE

The eggs are spherical, clear to pale green in color, and shiny. They are usually found on the undersides of the leaves where adult feeding activities are present. They are attached to the leaves in the webbing left by the adults.

The first instar is a six-legged stage called a larva and is similar in shape and color to the adult.

The adult is an eight-legged mite, ranging in color from shades of green to brown. The male is smaller than the female, has a narrower, pointed abdomen. Both sexes have sparse spines and two dark pigmented areas on the back. These pigmented areas are food particles which can be seen through the body wall.

LIFE CYCLE

This non-insect pest goes through four stages of development: egg, larva, nymph, and adult.

After being deposited, the egg will hatch in 3-19 days, depending upon temperatures. After hatching, the 6-legged larva will immediately start to feed on the leaves. It will later change into an 8-legged stage, and then to an adult in about 19 days, during which time continual feeding occurs.

There are several continuous generations per year in greenhouses, but this mite can overwinter outdoors as an adult female in N.H.

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CONTROL

NURSERY:

Spray the undersides of leaves on elm, linden, rose, and ornamental fruit trees in late May to mid-June, and again in mid-July to early August. The following materials are recommended:

dicofol (Kelthane)
tetradifon (Tedion)

chlorobenzilate WP
Meta-Systox-R*

GREENHOUSE:

Foliage Spray:

chlorobenzilate WP
demeton (Systox)*
diazinon EC
dimethoate (Cygon or De-fend) EC
azinophos-methyl (Guthion)*
dicofol (Kelthane) EC or WP
Meta-Systox-R* SC

Morestan WP
naled (Dibrom) EC
parathion* 15WP
Pentac WP
Tepp* EC
tetradifon (Tedion) WP

Granular:

disulfoton (Di-Syston)*
aldicarb (Temik)*

Aerosol:

sulfotepp (Dithio)*

SUMMARY

- | | |
|-------------------------------------|---|
| 1. Damaging Stage: | All Active Stages |
| 2. Part of Plant Attacked: | Leaves |
| 3. Overwintering Stage: | All Stages in the Greenhouse
In Nursery, Adult Females |
| 4. Number of Generations Per Year: | Several Indoors; 8-10 Outdoors |
| 5. Time of Year When Damage Done: | Outdoors: Late May-Early June, Late July-
Early Aug. Indoors: Year Round |
| 6. Number of Applications Per Year: | Variable |

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed on the label to be in compliance with the law.

James S. Bowman
Jon P. Turnel

Extension Entomologists

1/76/1.5M

COOPERATIVE EXTENSION SERVICE

University of New Hampshire

PESTICIDE APPLICATOR TRAINING

SMALL FRUITS

ORNAMENTALS AND TURF



Pest Fact Sheet

No. 23



JAPANESE BEETLE



I

INTRODUCTION

The Japanese Beetle, *Popillia japonica*, was first introduced into this country on the roots of nursery stock from Japan to New Jersey in 1916. Today, it can be found in all states east of the Mississippi River.

DESCRIPTION OF THE JAPANESE BEETLE

The adult Japanese Beetle is 12 mm in length and is broadly oval. The entire body is a metallic greenish-bronze with dark green legs and coppery-brown wing covers. Two small tufts of white are found behind the wing covers on the abdomen and five smaller patches on the side of the abdomen. All white patches can be seen when the adult is at rest because the wing covers are shorter than the abdomen.

The immature stage is the larva. It is a C-shaped white grub with an orange-yellow head capsule. When fully grown, it is 25 mm in length.

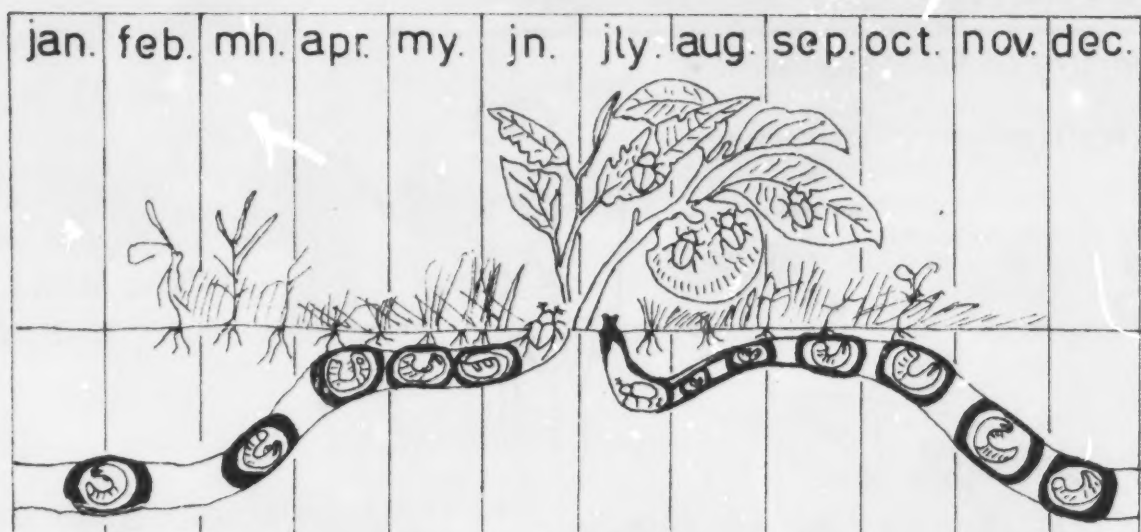
LIFE CYCLE

The Japanese Beetle overwinters in N.H. as a larva in the soil. In early spring, pupation occurs and the adults emerge in early June. Peak emergence occurs in July. The adults feed on nearby fruit and foliage. After mating, eggs are deposited in the soil 2-6" deep. Upon hatching, the grub will feed on decaying vegetation only to later feed on roots of grasses and other plants as development continues. There is only one generation per year in N.H.

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CONTROL

Grapes: Adult beetle control; apply when beetles appear in numbers.

carbaryl (Sevin) 2 lbs/100

methoxychlor 2 lbs/100

Ornamentals: Adult beetle control; apply according to label directions when beetles appear in numbers.

carbaryl (Sevin); methoxychlor; diazinon

Turf: Grub control

diazinon or Dursban

Milky Spore Disease; Note: do not use on areas treated with insecticides. Grubs must be present to spread and maintain disease.

SUMMARY

1. Damaging Stage and Plant Parts Attacked: Adult: foliage -- Immature: turf roots
2. Overwintering Stage: Larva
3. Number of Generations Per Year: One
4. Time of Year When Damage Done: Grapes and Ornamentals: June-July
Turf: July, August, September
5. Number of Applications Per Year: 1-2

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed on the label to be in compliance with the law.

James S. Bowman

Jon P. Turnel

Extension Entomologists

COOPERATIVE EXTENSION SERVICE

University of New Hampshire

Pest Fact Sheet

No. 29

PESTICIDE APPLICATOR TRAINING

ORNAMENTALS



FALL WEBWORM
AND
EASTERN TENT CATERPILLAR



fall webworm



eastern tent caterpillar

INTRODUCTION

The Fall Webworm (*Hyphantria cunea*, Drury) and the Eastern Tent Caterpillar (*Malacosoma americanum*, Fabricius) feed on fruit, shade, and woodland trees. They are of little economic importance in orchards which are regularly sprayed for the control of Codling Moth and other pests, but because they form unsightly webs, they can be considered a significant pest of nurseries and landscape. The Fall Webworm is frequently confused with the Gypsy Moth. The dirty loosely-woven web of the Fall Webworm encloses branches; the larvae can be found feeding within the web. The web of the Eastern Tent Caterpillar, on the other hand, is thickly constructed in the forks and crotches of trees; the larvae do not feed within their webs, but congregate there at night and during rainy weather. Fall Webworm occurs in the fall, whereas Eastern Tent Caterpillar occurs in the spring.

DESCRIPTION

FALL WEBWORM: The full-grown larvae are about $1\frac{1}{2}$ " long. They may be yellow with dark stripes and spots, or they may be dull bluish black with no yellow. The body is very hairy and the head is dark. The adult moths have a wingspan of $1\frac{1}{2}$ ". Their color is nearly pure white.

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EASTERN TENT CATERPILLAR: The full-grown larvae are about 2" long and have sparse hairs. They are black with white and blue markings and have a white stripe down the middle of the back. The adult moths are reddish-brown in color with two whitish stripes running obliquely across each forewing.

LIFE CYCLE

FALL WEBWORM: There is one generation of the Fall Webworm per year. It overwinters as a pupa in the soil. In June and July, adult moths emerge from the soil and the females begin laying eggs in July. The eggs begin to hatch in late July - early August, and the larvae feed within the web for a month or more, crawl down the tree, construct a cocoon, and pupate.

EASTERN TENT CATERPILLAR: There is one generation of the Eastern Tent Caterpillar per year. It overwinters in egg masses on twigs of trees. They hatch in the spring, about the time the buds open. After feeding for two days, the larvae weave their tent. Successive layers are added to the tent as the larvae develop. Early in the summer, the larvae spin a cocoon, pupate, and emerge as adults. The females deposit masses of eggs in bands around twigs. The larvae develop inside the eggs, but do not hatch until the next spring.

CONTROL

Early detection of nests of either pest is important to avoid excessive defoliation. Destroying the nests by pruning out or burning can be done to a limited extent. Pesticides should be applied to hard-to-reach infestations or when populations are heavy. Spray foliage with methoxychlor, carbaryl, diazinon, Dylox, or Bacillus thurengiensis according to the label.

SUMMARY

	<u>Fall Webworm</u>	<u>E. Tent Caterpillar</u>
1. Damaging Stage:	Larvae	Larvae
2. Part of Plant Attacked:	Leaves	Leaves
3. Overwintering Stage:	Pupa	Egg
4. Number of Generations Per Year:	One	One
5. Time of Year When Damage Done:	Fall	Spring
6. Number of Applications Per Year:	As Needed	As Needed

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed on the label to be in compliance with the law.

James S. Bowman
Extension Entomologist

COOPERATIVE EXTENSION SERVICE

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Pest Fact Sheet

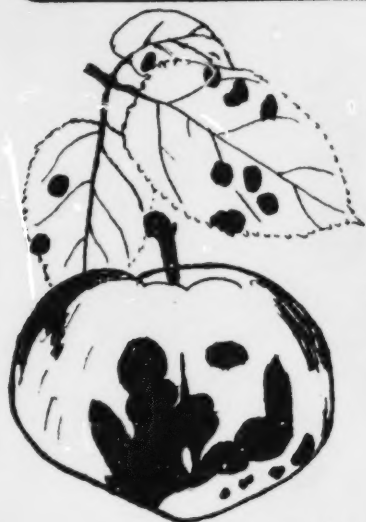
No. 31

PESTICIDE APPLICATOR TRAINING

TREE FRUIT



APPLE SCAB



INTRODUCTION

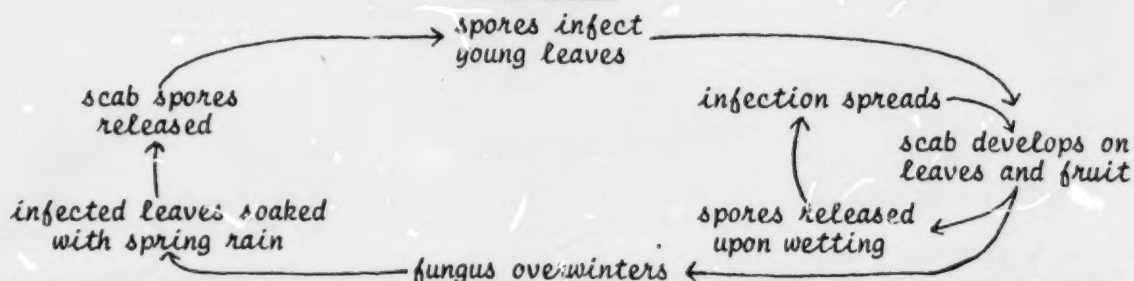
Apple Scab is a fungus disease that occurs wherever apples are grown. It is most severe in areas where the climate is cool and moist; thus, New Hampshire is an area particularly vulnerable to Apple Scab. It is more of a problem today than 50 years ago because of the increased production of highly susceptible varieties of apples (such as McIntosh) and the subsequent build-up of the Apple Scab pathogen. Apple Scab is a significant, economic disease of apples which reduces the size and quality of the infected fruit and reduces the length of time the fruit can remain in storage.

DESCRIPTION OF APPLE SCAB

The symptoms appear on both leaves and fruit. Lesions on the leaf first appear as olive-colored irregular spots that later become larger and velvety as the leaf develops. The number of lesions per leaf varies with the severity of the infection. They may remain distinct or may coalesce. After severe early infection the leaves may curl and fall.

Infections of the fruit appear as distinct, almost circular scab lesions at first velvety and olive-green but later become darker, scabby, and sometimes cracked. Severe early infection of fruit results in deformed, cracked fruit which may drop. Late infections may develop into dark scab spots during storage. Multiple infections occur throughout each season.

LIFE CYCLE



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CONTROL

Apply protectant fungicide sprays at green tip (when first susceptible tissue emerges from the bud and first primary spores are discharged), half-inch green, tight cluster, pink, bloom, and petal fall to protect developing leaves, flowers, and fruit from infection during this critical part of the growing season. The interval between these sprays is generally 3-8 days, depending on the rainfall and the rate of growth. Apply cover sprays throughout the summer at 7-14 day intervals, depending on the weather.

<u>FUNGICIDE</u>	<u>RATE/100 GALS.</u>	<u>RATE/ACRE</u>	<u>AFTER-INFECTION¹</u> <u>ACTIVITY</u>	<u>DAYS TO</u> <u>HARVEST</u>
benomyl (Benlate) 50WP	4-6 oz.	12-18 oz.	18-24 hrs.	0
captan 50WP	1 lb.	3 lb.	18-24 hrs.	0
dichlone (Phygon) 50WP	4 oz.	12 oz.	30-36 hrs.	PF ²
dodine (Cyprex) 65WP	6 oz.	18 oz.	18-24 hrs.	5
Dikar 80WP	2 lb.	6 lb.	none	30
ferbam (Fermate) 76WP	1½ lb.	4½ lb.	none	7
maneb/zinc 80WP	1½ lb.	4½ lb.	18-24 hrs.	30
Polyram 80WP	1-1½ lb.	3-4½ lb.	18-24 hrs.	30
thiram (Thylate) 65WP	4-6 oz.	12-18 oz.	15-20 hrs.	0

¹Hours from beginning of rain resulting in an infection period at optimum temperatures (50-60°F) for scab development. At 50°F the eradication period is the higher figure given; at 60°F it is the lower time period. The fungicides will provide effective eradicant action if applied within the time period listed.

Use as an emergency measure after infection is presumed to have taken place, but before the time limit of after-infection activity for the fungicide has been exceeded.

²Not recommended for use on Red Delicious or Golden Delicious or after Petal Fall.

SUMMARY

1. Causal Agent: Fungus
2. Plant Parts Attacked: Foliage and Fruit
3. Major Symptoms: Scab Lesions on Foliage and Fruit
4. Time of First Noticable Symptoms: When Leaves Become Fully Expanded
5. Spray Program: Protectant Sprays with Eradicant Sprays when Necessary
6. Number of Applications Per Season: 12-15

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed on the label to be in compliance with the law.

COOPERATIVE EXTENSION SERVICE

University of New Hampshire

Pest Fact Sheet

No. 37

PESTICIDE APPLICATOR TRAINING

ORNAMENTALS



SCALE INSECTS



Oyster Shell
Scale



Euonymus
Scale



Fletcher
Scale



Cottony Maple
Scale

DESCRIPTION OF SCALE INSECTS

In appearance, scales in general show little resemblance to the typical insects. They are well protected because they live under a waxy, almost impermeable shell. The female lays her eggs under the shell which offers them protection. When the eggs hatch, the "crawler" stage is motile and will crawl about on the host plant to select a feeding site. It is during the crawler stage of development that scales are easily killed with insecticides.

Except for the males of some species, adult scales are permanently affixed to a position selected during the crawler stage. Scale infestations frequently go undetected until the infected plant is completely encrusted. The needle-like mouth parts are inserted into the plant and sap is withdrawn. Scales also secrete a clear sticky substance called honeydew which will coat objects below infested plants. Honeydew in turn will support the growth of a black fungus called sooty mold.

Scale insects vary in size, shape, color, host preference, and life cycle. The following species are common to New Hampshire trees and shrubs.

1. Oyster Shell Scale: Brown oyster shell shape about 1/8" long. They are found on twigs of lilac, ash, red bud, dogwood, poplar, willow, horsechestnut, elm, beech, walnut, cottoneaster, apple, birch, pachysandra, and others. The winter is passed as white eggs under the scale coverings. The eggs hatch in May, about the time the lilac blooms begin to fade. They become mature by August. There is one generation per year.

2. Euonymus Scale: This scale is obvious as brownish encrustations of the stems and twigs, and whitish spotting of the leaves, mainly on the underside. The primary

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host is euonymus, but it is also found on pachysandra and celastris (bittersweet). The winter is spent as the female on the stems and leaves. The young crawlers are produced in May or early June. A second generation occurs in mid-summer.

3. Fletcher Scale: The adult female is light yellowish-brown, almost globular, and about 3-5 mm in diameter. It commonly attacks Taxus, juniper, and arborvitae. It overwinters as a female and the eggs are laid in late May and hatch by early July. Foliage on the inner portions of heavily infested plants is often blackened by the sooty mold growing on the honeydew excreted by the scales. There is one generation per year with crawlers appearing again.

4. Cottony Maple Scale: This scale is best identified by the mass of white wax protruding from beneath brown scales, about 1/2" long. It is found on maple, boxelder, basswood, ash, sycamore, beech, black locust, willow, poplar, and occasionally elm; the favorite host is silver maple. The overwintering female lays eggs from April to June and they hatch in June and July. In heavy infestations branches may be killed, the foliage turns a sickly yellow, and honeydew drips on objects below upon which sooty mold grows.

CONTROL

SPECIES	STAGE	WHERE TO TREAT	WHEN TO TREAT	WHAT TO USE
Oyster Shell Scale	Egg	Bark of Twigs and Branches	April	60-70 sec. oil or oil + ethion
	Crawler	Bark of Twigs and branches	Late May to Early June	carbaryl or malathion + methoxychlor
Euonymus Scale	Nymph	Twigs and Stems	Mid-April to Early May	60-70 sec. oil or oil + ethion
	Crawler	Twigs and Stems	Early to Mid-June	malathion + methoxychlor or dimethoate or <u>Meta-Systox-R*</u> or carbaryl
Fletcher Scale	Nymph	Foliage and Twigs	Mid-April to Early May	60-70 sec. oil or oil + <u>Guthion*</u>
	Crawler	Foliage and Twigs	July and Sept.	malathion or carbaryl or diazinon or <u>Meta-Systox-R*</u>
Cottony Maple Scale	Crawler	Twigs	Late June and July	malathion or carbaryl

* Restricted use pesticide in N.H.

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed on the label to be in compliance with the law.

COOPERATIVE EXTENSION SERVICE

University of New Hampshire

Pest Fact Sheet

No. 38

PESTICIDE APPLICATOR TRAINING

ORNAMENTALS



SPRUCE GALL APHIDS

INTRODUCTION

Most spruce trees are damaged by one of two species of aphids, the Eastern spruce gall aphid (*Adelges abietis* L.) and the Cooley spruce gall aphid (*Adelges cooleyi* Gill.). With their sucking mouthparts, they feed on plant juices causing an irritation to adjacent plant tissue which then develops into cone-like galls which are characteristic in form and shape for the aphid species involved. Continued infestations will disfigure ornamental trees, weakening them and making them subject to attack by other pest organisms.

DESCRIPTION AND LIFE CYCLE

Eastern Spruce Gall Aphid: Galls caused by this insect occur mostly on Norway, white, black, and red spruce trees. An infestation does not spread rapidly from one tree to another. It is not unusual to find specific trees in a planting rather heavily infested year after year while others of the same species may escape injury.



The Eastern spruce gall aphid lives during the winter as an immature female, usually located in a crevice at the base of a spruce bud. It begins feeding in early spring and in May deposits a mass of eggs which is covered with waxy threads. The eggs hatch about the time the shucks break away from the bud and expose the new needles. The newly hatched aphids crawl into the mass of new needles to feed. The swelling needle bases develop into a compact mass and form the pineapple-shaped gall with many individual cells, each inhabited by many aphids. In late July or August, the cells open and the aphids escape. These escapees deposit the eggs producing the individuals which live through the winter.

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Cooley Spruce Gall Aphid: Galls caused by the Cooley spruce gall aphid occur on Colorado blue spruce, Sitka spruce, and Engelmann spruce. The galls are somewhat larger than those caused by the Eastern spruce gall aphid and occur on the tips of twigs. The growing gall varies from light green to dark purple. It may be 1 to 2" in length and $\frac{1}{2}$ to $\frac{3}{4}$ " in diameter.

The life history of this aphid, when it remains on spruce, is similar to that of the Eastern spruce gall aphid. However, some of the mature aphids emerging from a gall in July or August fly to Douglas fir to lay eggs. The eggs hatch into young aphids which live during the winter on fir and produce a new brood in the spring when growth appears. These feed on the new growth and may cause some distortion but do not form galls.

CONTROL

MATERIAL

60 or 70 sec oil or oil + ethion¹

WHEN TO TREAT

Before buds break in mid to late April

REMARKS

crevices of bark or tips of twigs and base of buds on Norway and white spruce for Eastern Spruce Gall Aphid and on blue spruce and Douglas fir for Cooley Spruce Gall Aphid

carbaryl (Sevin) or malathion Same as above or endosulfan*

same as above

¹Do not use on blue spruce as it will discolor it.

*Restricted use pesticide in N.H.

SUMMARY

	<u>Eastern Spruce Gall Aphid</u>	<u>Cooley Spruce Gall Aphid</u>
1. Damaging Stage:	Young and Adult	Young and Adult
2. Plant Parts Attacked:	New Needle Mass	New Growth
3. Overwintering Stage:	Immature Female	Young on Doug. Fir or Immature Female on Blue Spruce
4. Number of Generations Per Year:	One	One
5. Time of Year When Damage Done:	Early Spring-Summer	Spring-Summer
6. Number of Applications Per Year:	One	One

SAFE USE OF PESTICIDES

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COOPERATIVE EXTENSION SERVICE

University of New Hampshire

Pest Fact Sheet

No. 39

PESTICIDE APPLICATOR TRAINING

TURF



INSECT PESTS
OF LAWNS AND TURFGRASS

INTRODUCTION

Lawn and turfgrass are subject to injury by a number of insects. These pests can cause serious damage and result in considerable repair and replacement expenses. However, through the proper use of chemicals and management, these pests can be controlled. For any control program to be effective, the homeowner or commercial turf grower should be familiar with the biology and seasonal development cycle of the various pests.

WHITE GRUBS



roster

White grubs are the larval or grub stage of several species of beetles and chafers. The two most common in New Hampshire are the Japanese Beetle and the June Bugs. These beetle larvae are usually C-shaped (except for the masked chafer), and can be found feeding among the roots of grass. They are typically cream colored with a brown head, and with a dark area at the posterior end where the body contents show through the skin. White grubs feed on grass roots and most complete their development in one year (some June beetles require 2 or 3 years).

Life Cycle and Damage

Summer: Eggs are laid in July and August, the adult beetle selecting the best grass available to deposit the eggs. The young grubs begin feeding on the grass roots within 1 or 2 weeks. Fall: Feeding goes on until fall when the grubs burrow deep into the ground to overwinter. Spring: In the spring, the grubs burrow upwards to the grass root level and resume feeding until late May, when they transform to the pupal stage. Adults begin emerging from the ground about the first week in June for the June Beetle and the first week of July for the Japanese Beetle. See Fact Sheet No. 23 for Life Cycle.

Evidence of an infestation of white grubs appears as areas of grass begin to turn brown (due to root damage). Usually the turf can be rolled back like a rug to reveal the white grubs.

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Description of Adults and Grubs

The term "White Grub" is commonly used to describe the larvae of both the Japanese Beetle and the June Beetle. They do similar damage and require similar chemical control measures. However, the biological control using milky spore dust only controls the Japanese Beetle, making it necessary to correctly identify the grub. (See controls)



rastral
pattern



adult

Japanese Beetle: The adult Japanese Beetle is about $\frac{1}{2}$ " long, with a shiny metallic-green head and body. The grubs are usually small, with a light brown head. The rastral pattern on the grub forms a V.



rastral
pattern



adult

June Beetle: There are over 200 species of these beetles in the U.S. All the adults are brown to nearly black, and range in size from $\frac{1}{2}$ " to 1". Most species complete development in a year, although some require 2 or 3 years. The adults are often attracted to lights at night. The grubs are larger than Japanese Beetle grubs, and are usually abundant in cultivated soils and crop areas. The rastral pattern forms an oval.

CHINCH BUGS



Chinch bugs are small, white and black insects that suck sap from grass. They may occur in large numbers and remain unnoticed for some time.

Life Cycle and Damage

Spring: The overwintering adults emerge and move to the rapidly growing grass plants. The adults feed and begin mating. The females lay about 200 eggs over a 3 to 5 week period. The young bugs (nymphs) begin feeding on the grass within 2 weeks. Summer: The nymphs molt about 5 times to become adults. They continue to feed on the plant sap. The adults in the summer produce a second generation of bugs. Fall: Adults of the second generation hide in grass clumps and leaf litter to spend the winter. When the weather warms in the spring they leave hibernation and search for food.

Most of the damage is caused by the nymphs as they suck plant juices from young grass. An infestation of chinch bugs shows up as yellow patches in the lawn or turf. The injured grass turns yellow, then brown as feeding continues. The chinch bugs concentrate their feeding at the edge of the patch on the healthy grass.

Test for Presence

Cut both ends out of a large tin can. At the edge of an infested or yellow area in the lawn, push one end of the can into the soil. Fill the can with water (keep full), and look for chinch bugs to float to the surface.

SOD WEBWORMS



Sod webworms are the larval or caterpillar stage of several species of Lepidoptera. The adults are commonly seen flying in jerky, short flights from place to place as you walk through the grass. They are often seen near lights at night. Although there are several species of sod webworms, they all do similar damage.

Life Cycle and Damage

Spring: When the weather warms, the overwintering caterpillars resume feeding on the grass. Soon the webworm caterpillar is full-grown and forms a pupa. Summer: Adults live for only a short period, they mate and lay eggs in the grass. The caterpillars build silken tunnels at the ground level. They come out at night to feed on the blades of grass. The caterpillars often cut off a piece of grass and return to their tunnel to eat. There may be 2 generations during the summer. Fall: The second generation of caterpillars remain in their tunnels in hibernation during the winter.

Sod webworms seem to prefer new lawns, attacking bent grass, bluegrass, fescue, etc. Damage first appears as small brown areas in the grass. The turf often has a ragged appearance.

ARMYWORMS AND CUTWORMS



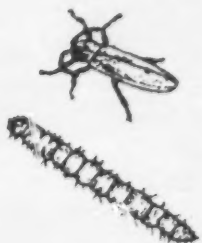
Armyworms and cutworms are the caterpillars of several species of night-flying moths. The caterpillars feed on the above-ground parts of plants (grain and forage crops, grasses, etc.). They are usually considered pests of crops. But infestations are also common in lawns and turf, especially where these areas border crop land or large untended fields. The caterpillars are capable of migrating from one area to another to feed.

Life Cycle and Damage

Spring: The overwintering caterpillars begin feeding when the weather warms. This causes damage to plants early in the growing season. The caterpillars soon become full-grown and form pupae. Summer: Adults appear in June and July. They fly at night and are attracted to lights. The females lay about 500 eggs (over a 2 to 3 week period) on the lower leaves of grasses. The small caterpillars begin feeding immediately, and may migrate to other areas if there is not enough food. The caterpillars usually hide by day and feed at night. There may be a second generation in the summer. Fall: The caterpillars stop feeding in the fall, and either form pupae or seek shelter in dead leaves on the ground to hibernate.

Both the armyworm and cutworm caterpillars can feed on weeds, cultivated plants, and grasses. They infest lawns and feed on grass blades (armyworm) or cut off plants near the soil level (cutworms). The grass takes on a ragged appearance and may turn brown. Since they feed at night, the caterpillars usually go unnoticed.

WIREWORMS



Wireworms are the larvae of certain beetles, commonly known as click-beetles. The "worms" or larvae are brown to dark brown, and smooth or nearly shiny. They can be found just below the grass roots in the soil. The larvae feed on grass roots. The adults do no damage.

<u>CONTROL</u>			
	<u>Material</u>	<u>Rate</u> <u>lb.ai/acre</u>	<u>Remarks</u>
Grubs (Japanese and June Beetle)	diazinon	6.0	Treat annually during July 15 - Aug 31. Apply ½-1" water immediately after treatment.
	or chlorpyrifos (Dursban)	2.0	
Japanese Beetle Grubs Only	Milky Spore Disease Dust	8.0 lb. dust	Do not use on areas treated with insecticides. Grubs must be present to spread and maintain disease. Do not expect results for 3-4 years. To prevent damage to good turf, use insecti- cides.
Hairy Chinchbug	carbaryl (Sevin)	8.0	Water prior to treatment with liquids and after treatment with granulars. Aspon and Carbaryl are least hazardous. Treat- ments for grubs are not effective against chinch- bugs. Apply treatment in early June. Only one ap- plication of Aspon is nec- essary. A second treat- ment of other materials may be needed in 2-3 weeks.
	or diazinon	4.0	
	or Aspon	7.0	
	or chlorpyrifos (Dursban)	1.0	
Armyworms Cutworms Sod Webworm	carbaryl (Sevin)	8.0	Evening applications are preferred and should not be watered after treatment. Avoid spraying before rain. Do not cut grass for 1-3 days after treatment.
	or diazinon	6.0	
	or chlorpyrifos (Dursban)	1.0	

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed on the label to be in compliance with the law. Avoid inhaling dusts or sprays. Open windows and ventilate the rooms while using pesticides. Never smoke or eat while spraying or dusting. Remove or cover food, feed, water, kitchen utensils and fish and other pets. Do not allow children near you when applying pesticides. Wash and clean up after using pesticides - change clothes if any pesticide was spilled. Dispose of empty containers safely. Bury 18" deep in an isolated area away from any water supply or place in a trash container. Do not burn aerosol cans. Store pesticides in their original containers in a locked cabinet or shed away from food. Be sure tops or caps are on tight. In case of an accident, follow label directions and call a physician immediately.

James S. Bowman
Extension Entomologist

COOPERATIVE EXTENSION SERVICE

University of New Hampshire

Pest Fact Sheet

No. 40

PESTICIDE APPLICATOR TRAINING

ORNAMENTALS



SAWFLIES

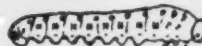
INTRODUCTION

A number of sawfly species are important defoliating pests of ornamental trees in New Hampshire. The damage is done by the larvae which are caterpillar-like, resembling moth or butterfly (lepidopterous) larvae. The way to tell the difference is to count the number of pairs of prolegs on the abdomen; sawfly larvae have 6 or more pairs while lepidopterous larvae have 5 or less pairs which bear small hooks called crochets. Another distinguishing characteristic is the number of eyes on the side of the head capsule. Sawfly larvae have one on each side while lepidopterous larvae usually have 6 on each side. Sawfly larvae often feed in groups (are gregarious) and strip one branch of needles or leaves before moving on to another branch. On conifers they prefer old needles but some species will also feed on new growth. Severe defoliation can cause the trees to die.

When mature, the larvae spin tough capsule-like cocoons on the ground or in the litter; sometimes on the tree. The wasp-like adults emerge from these and lay eggs singly in slits cut in the needles of the food plant. These slits are cut by a saw-like ovipositor, from which sawflies get their name.

The following species of sawflies are important pests in New Hampshire.

Red-Headed Pine Sawfly (*Neodiprion lecontei* Fitch)



This sawfly is one of the most destructive of the native species of sawflies attacking pine. Pines having needles in clusters of two to three are preferred, such as red, Scotch, mugho, jack, pitch, lodgepole, slash, Japanese red, and Virginia pines. Occasionally Eastern white pine may be attacked.

Fully grown larvae are yellowish-white with six rows of conspicuous black spots and the head is reddish.

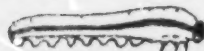
The winter is spent as a prepupa in a capsule-like cocoon in the ground. After pupation the emerged female lays eggs in the previous years needles. The newly hatched larvae feed in groups on new and old needles defoliating the branches. They become full grown in 25-31 days. When ready to pupate, they drop to the ground and spin a reddish-brown cocoon. There can be more than one generation per year.

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European Pine Sawfly (*Neodiprion sertifer* Geoff)



This species was introduced in the U.S. in 1925 and is now established throughout New England. It prefers red and Scotch pine and also attacks mugho, jack, Japanese red, and Swiss mountain pine. Trees stripped in successive years may die. Full grown larvae are grayish-green and about 7/8" long. There is a lighter longitudinal stripe down the middle with two whitish lines on the sides which border a greenish or blackish stripe which can be broken into a series of spots. The head and thoracic legs are black.

The winter is spent in the egg stage in the old needles and hatch in April to mid-May. The larvae feed gregariously on older needles and do not injure new growth. Pupation occurs in late August or early September. Adults emerge in September and lay eggs in the current needles. There is one generation per year.

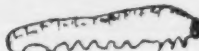
Introduced Pine Sawfly (*Diprion simile* Htg.)



This species was introduced from Europe in 1914 and is now present throughout the northeast. It prefers white pine but also feeds on Scotch, red, jack, and mugho pines. When full grown, the larva is about one inch long with a black head and greenish-yellow body with a double brown or blackish stripe the entire length of the back. The sides of the body are dark brown mottled with yellow and black.

The winter is spent as a prepupa with adults appearing from May to mid-June. The eggs are deposited in the edge of older needles. Young larvae feed gregariously while older larvae feed singly. There can be two and a partial third generation per year.

Larch Sawfly (*Pristiphora erichsonii* Hartig)

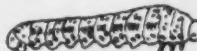


This introduced species was first recorded in Mass. in 1880 and now occurs in the northern tier of states. Its preferred host is larch (tamarack). Fully grown larvae are whitish beneath and gray-green along the dorsum, with a black head.

The winter is spent in the prepupal stage and adults appear from mid-May to August, depending on the location and temperature. Eggs are laid under the bark on current growth and hatch in about 8 days. The young larvae migrate to the foliage of older twigs where they usually feed in group. After about 20 days they fall to the ground and pupate. There is normally one generation per year.

Defoliated trees are usually not killed because some regrowth during the same season occurs. However, reduction in normal growth occurs.

Mountain Ash Sawfly (*Pristiphora geniculata* Hartig)



This species was introduced from Europe in 1925 and now occurs throughout New England. Its primary hosts are American and European ash. Full grown larvae are pale greenish to yellow with yellow heads and yellow thoracic legs. The body segments are marked with black spots of uneven size and shape, occurring in irregular rows.

The winter is spent in the prepupal stage and adults appear in late May to early July. Eggs are laid in slits around the edge of leaflets and hatch in one week. Newly hatched larvae straddle the edge of leaves and when disturbed, raise their abdomen in the form of an "S". Young larvae are gregarious while older larvae feed singly. Everything is eaten of the leaves except the midribs. Complete defoliation usually does not occur and defoliated trees usually survive.

CONTROL

Sawfly larvae are easily controlled by treating with either methoxychlor or carbaryl when the larvae appear.

COOPERATIVE EXTENSION SERVICE

University of New Hampshire

Pest Fact Sheet

No. 41

PESTICIDE APPLICATOR TRAINING

TURF



SCLEROTINIA DOLLAR SPOT

INTRODUCTION

Dollar spot fungus affects a wide variety of grasses including Bermudagrass, ryegrass, St. Augustine, zoysia, fescue, and bentgrass.

DESCRIPTION

The overall symptom pattern for Sclerotinia dollar spot varies with mowing practices. Under close mowing, as with golf greens, the disease progresses from the very small initial spots of dead turf to distinctly circular, straw-colored areas 2-3" in diameter, sharply outlined against the surrounding healthy grass. With the higher cutting practices characteristic of home lawns, the small, sharply outlined spots of the golf greens are replaced by larger, irregularly-shaped, straw-colored areas of dead grass ranging from 6-12" in diameter. Under these conditions the disease can be mistaken for drought injury.

Affected individual grass leaves first show yellow-green blotches that become water-soaked and finally bleached to a straw-colored tan with reddish-brown margins. Entire leaves are usually blighted, but in some cases only portions of the leaf tissue are killed. In the early morning hours, while dew is still present on the leaves, a cobwebby white, mold-like growth of the causal fungus appears on the affected leaves.

DISEASE CYCLE

The causal fungus overwinters in or on the soil in the form of hard resting bodies called sclerotia and in the crowns and roots of infected grass plants. In the early summer (when the temperature reaches 60°F) the organism begins growth, reaching a peak of activity during humid weather with temperature from 70°F to 80°F.

Spread of the pathogen to new areas occurs primarily by transport of infected plant material with mowers, traveling irrigators, and other maintenance equipment.

Grass growing under low soil moisture conditions is more susceptible than when adequate soil moisture is provided. Hence, severe outbreaks of the disease can and do occur during seasons of low rainfall.

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Sclerotinia dollar spot is less of a problem in lawngrass growing in soil of high nitrogen fertility. It has been shown, however, that resistance to the pathogen actually decreases with increased nitrogen fertility; and that the beneficial effect of high nitrogen nutrition is due to faster plant recovery during periods unfavorable for disease development. Soil pH does not influence disease development.

CONTROL

<u>FUNGICIDE</u>	<u>RATE IN OZ/1000 SQ.FT. *</u>
Acti-dione/Thiram	3
Daconil 2787	4
Dyrene	4
Tersan 1991	$\frac{1}{2}$ -1
Cleary 3336	$\frac{1}{2}$ -1
Fungo	$\frac{1}{2}$ -1
Spot Kleen	3/8-3/4
Mertect 160	$\frac{1}{2}$ -1

* Lower rates are to be used for preventive programs, higher rates for curative programs in 5-10 gals. water/1000 sq. ft.

Applications are made from June to September. There is good residual control (4-6 weeks) when systemics are used. Optimum control using protectants is achieved when fungicide applications are made at 7-14 day intervals during periods of disease outbreak.

SUMMARY

- | | |
|---------------------------------------|--|
| 1. Causal Agent: | Fungus |
| 2. Plant Parts Attacked: | Leaves |
| 3. Major Symptoms: | Spot in Leaves and Patches in Turf |
| 4. Time of First Noticable Symptoms: | Early Summer |
| 5. Spray Program: | Systemic Fungicides; Protectant Fungicides |
| 6. Number of Applications per Season: | 4-6 |

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed on the label to be in compliance with the law. Avoid inhaling dusts or sprays. Open windows and ventilate the rooms while using pesticides. Never smoke or eat while spraying or dusting. Remove or cover food, feed, water, kitchen utensils and fish and other pets. Do not allow children near you when applying pesticides. Wash and clean up after using pesticides - change clothes if any pesticide was spilled. Dispose of empty containers safely. Bury 18" deep in an isolated area away from any water supply or place in a trash container. Do not burn aerosol cans. Store pesticides in their original containers in a locked cabinet or shed away from food. Be sure tops or caps are on tight. In case of an accident, follow label directions and call a physician immediately.

COOPERATIVE EXTENSION SERVICE

University of New Hampshire

Pest Fact Sheet

No. 42

PESTICIDE APPLICATOR TRAINING

TURF



HELMINTHOSPORIUM
LEAF SPOT

INTRODUCTION

Helminthosporium leaf spot is a common foliage problem of bluegrasses, bentgrasses, fescues, and ryegrasses.

DESCRIPTION

On Bluegrasses: On bluegrasses, the leaf spots are first seen as small, purplish areas. As these spots increase in size, the centers turn brown and eventually fade to a light tan with purplish brown borders. Primary damage caused by the disease comes from blighting of the leaf tissue. This occurs as a rapid collapse and drying of the leaves -- after which they fade to a light straw color. During warm, humid weather of mid-summer, the whole process may occur within a period of 4-5 days from time of infection. The overall disease pattern appears as a brownish fading-out of turfgrass areas of various sizes.

On Bentgrasses: On bentgrasses, the disease is first seen as smoky-blue, irregularly shaped turf areas varying from 1-4 feet in diameter. Soon after, yellowing and complete killing of the grass plants takes place. Finally, these areas appear water-soaked and matted down. The first leaf symptoms are minute yellow flecks which soon progress to irregularly shaped, water-soaked blotches.

DISEASE CYCLE

The causal organism survives the winter in infected plants and infested debris from the previous year's stand. During the growing season, the organism also develops on grass clippings and dead tissues of living grass plants. On Kentucky bluegrass leaves, spores germinate in 30-40 minutes if weather conditions are favorable. At 78°F, a period of 8 to 10 hours with 100% relative humidity is all that is required for a high level of infection to occur.

The first leaf spots usually appear in late spring. Disease severity increases with the onset of warm summer weather and decreases with the cooler fall weather.

The leaf spot phase of disease development is frequently accompanied by a severe crown and root rot that reduces the vigor and drought tolerance of the plants.

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Severity of the disease is directly related to air temperature. At 68°F, leaf spotting occurs, with no leaf blighting; at 75°F, leaf spotting is predominant with a slight blighting occurring; at 85°F, leaf blighting is severe with very little leaf spotting; and at 95°F, leaf blighting is severe with no leaf spots appearing.

CONTROL

Resistant Varieties: The Merion variety of Kentucky bluegrass is more susceptible to *Helminthosporium* leaf spot than common Kentucky bluegrass.

Chemical Control: Applications can be made from June to September. Optimum control is achieved when fungicide applications are made at 7-14 day intervals during periods of disease outbreak.

FUNGICIDE

RATE IN OZ/1000 SQ.FT. *

Daconil 2787

4-6

Dyrene

4-6

Thiram

4-6

Manzate 200

4-6

Tersan LSP

4-6

Zineb 75%WP

4-6

Dithane N-45 (Fore)

4-6

Acti-dione/Thiram

2-4

Terraclor

4-6

* Lower rates are to be used for preventive programs, higher rates for curative programs in 5-10 gals. water/1000 sq. ft.

SUMMARY

1. Causal Agent: Fungus
2. Plant Parts Attacked: Leaves, also Crown and Root
3. Major Symptoms: Bright Yellow Leaf Blade or Distinct Yellow-Brown Leaf Spots with Darkened Borders
4. Time of First Noticable Symptoms: Early Summer
5. Spray Program: Preventive Fungicide Sprays
6. Number of Applications per Season: 1-4 applications

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed on the label to be in compliance with the law. Avoid inhaling dusts or sprays. Open windows and ventilate the rooms while using pesticides. Never smoke or eat while spraying or dusting. Remove or cover food, feed, water, kitchen utensils and fish and other pets. Do not allow children near you when applying pesticides. Wash and clean up after using pesticides - change clothes if any pesticide was spilled. Dispose of empty containers safely. Bury 18" deep in an isolated area away from any water supply or place in a trash container. Do not burn aerosol cans. Store pesticides in their original containers in a locked cabinet or shed away from food. Be sure tops or caps are on tight. In case of an accident, follow label directions and call a physician immediately.

William E. MacHardy
Extension Plant Pathologist

COOPERATIVE EXTENSION SERVICE

University of New Hampshire

Pest Fact Sheet

No. 43

PESTICIDE APPLICATOR TRAINING

TURF



POWDERY MILDEW

INTRODUCTION

Powdery mildew fungus occurs most commonly on the cool-season grasses such as Bermudagrass, bluegrasses, and fescues. It is most troublesome in the southernmost parts of the areas in which these grasses are grown.

DESCRIPTION

The fungus is usually first seen as isolated wefts of fine, gray-white cobwebby growth on the upper surface of the leaves. This growth rapidly becomes more dense, and may cover the entire leaf giving it a gray-white appearance. In cases of severe outbreaks, sections of entire grass stands may be dull white, rather than green.

DISEASE CYCLE

The pathogen survives the winter months in dead grass leaves from the previous season, and in a dormant state in infected grass plants.

Fungal spores are spread by air movement and germinate and the infection process begins within two hours from the time they land on the leaf.

Conditions favorable for the development of powdery mildew include: (a) reduced air circulation; (b) high atmospheric humidity, but no free water on the surfaces of the leaves; (c) low light intensity; and (d) an air temperature of 65°F.

The disease is usually more severe on turfgrass growing in shaded areas than in full natural light.

CONTROL

Resistant Varieties: Various grass varieties differ in their susceptibility to powdery mildew. Merion Kentucky bluegrass, for example, is more susceptible to the powdery mildew fungus than common Kentucky bluegrass. However, selection of common Kentucky, solely because of its higher powdery mildew resistance, cannot be justified because of other disease resistance and cultural characteristics entering the picture.

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Cultural Practices: Where powdery mildew is of frequent recurrence, changes to improve air movement and reduce grass shading will aid in disease reduction. Avoid high nitrogen fertility.

Chemical Control: In July-October, a single application of suitable fungicide after the disease appears will often give satisfactory control, but 2-3 applications at 4-6 day intervals may be required for complete eradication if the outbreak is severe.

<u>FUNGICIDE</u>	<u>RATE IN OZ/100 SQ. FT. *</u>
Acti-dione/Thiram	4
Karathane 22.5% WP	$\frac{1}{4}$ - $\frac{1}{2}$
Tersan 1991	1-2
Fungo	1-2
Spot Kleen	$\frac{3}{4}$ - $1\frac{1}{2}$
Cleary 3336	$\frac{3}{4}$ - $1\frac{1}{2}$

* Lower rates are to be used for preventive programs, higher rates for curative programs in 5-10 gals. water/1000 sq. ft.

SUMMARY

- | | |
|---------------------------------------|------------------------------|
| 1. Causal Agent: | Fungus |
| 2. Plant Parts Attacked: | Leaves |
| 3. Major Symptoms: | Mildew |
| 4. Time of First Noticable Symptoms: | Mid-Summer |
| 5. Spray Program: | Eradicative Fungicide Sprays |
| 6. Number of Applications per Season: | 1-3 |

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed on the label to be in compliance with the law. Avoid inhaling dusts or sprays. Open windows and ventilate the rooms while using pesticides. Never smoke or eat while spraying or dusting. Remove or cover food, feed, water, kitchen utensils and fish and other pets. Do not allow children near you when applying pesticides. Wash and clean up after using pesticides - change clothes if any pesticide was spilled. Dispose of empty containers safely. Bury 18" deep in an isolated area away from any water supply or place in a trash container. Do not burn aerosol cans. Store pesticides in their original containers in a locked cabinet or shed away from food. Be sure tops or caps are on tight. In case of an accident, follow label directions and call a physician immediately.

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3/76/5C-es

COOPERATIVE EXTENSION SERVICE

University of New Hampshire

Pest Fact Sheet

No. 44

PESTICIDE APPLICATOR TRAINING

TURF



RHIZOCTONIA BROWN PATCH

INTRODUCTION

Rhizoctonia brown patch is a common fungal disease of all commonly cultivated lawngrasses. It develops most readily at temperatures between 80-85°F. In addition to ideal temperatures and humid weather, heavy applications of nitrogen fertilizer favor disease development. Brown patch is characterized by roughly circular areas which may be a few inches to several feet in diameter.

DESCRIPTION

On close-cut grass, such as on golf and bowling greens, Rhizoctonia brown patch appears as light brown irregularly-shaped areas ranging from a few inches up to 2 feet in diameter. The coloration of these patches is at first a purplish green, but they rapidly fade to light brown as the leaves dry out.

Where high mowing is practiced, i.e., on home lawns, park lawns, and golf course fairways, the diseased areas range from 2 feet to 50 feet in diameter. These patches of light brown grass are more or less circular in outline and usually are closely appressed to the soil surface, creating a sunken or "pocket" effect.

The chief distinguishing feature of Rhizoctonia brown patch appears during periods of warm, humid weather, when dark, purplish "smoke rings," $\frac{1}{2}$ to 2" wide, may border the diseased areas. The "halos" are more pronounced in the hours of early morning, usually fading by the middle of the day.

DISEASE CYCLE

The causal fungus survives from year to year in the form of resting bodies called sclerotia either within infected grass tissue or on the surface of the soil. The fungus is also capable of existing as a soil inhabitant for long periods in the absence of susceptible grass. Growth of the pathogen from the winter resting stage occurs when air temperatures reach 64°F.

Fungus penetration of the leaves may take place when the average daily air temperature reaches 73°F. Invasion of the leaf tissue occurs through leaf pores and wounds produced by mowing. Infection and disease development are slow at this temp-

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erature. However, when the air temperatures reach 80-85°F, particularly at 100% relative humidity, optimum conditions for infection are present and the fungus may completely blight a large area of turf within a period of 6 to 8 hours. When the air temperature reaches 90°F, parasitic activity of the fungus stops.

Although the disease may occur at low humidities, rainy weather and a saturated atmosphere (100% relative humidity) greatly speed disease development. Free moisture must be present on the leaves for the fungus to spread rapidly to healthy plants.

CONTROL

Fungicide applications can be made from July to September. Turfgrass species and varieties show different levels of susceptibility to Rhizoctonia brown patch. A preventive fungicide program is necessary to effectively control this disease on the highly susceptible species. Apply the first spray immediately after the first occurrence of night temperatures that do not drop below 70°F and continue at 5-10 day intervals if the daytime temperatures are 80°F or above and conditions of high humidity prevail. Avoid high nitrogen fertility.

<u>FUNGICIDE</u>	<u>RATE IN OZ/1000 SQ.FT. *</u>	
Thiram	4-6	
Tersan LSR	4-6	
Daconil 2787	4-6	* Lower rates are to be used for preventive programs, higher rates for curative programs in 5-10 gals. water per 1000 sq. ft.
Dithane M-45	4-6	
Acti-dione/Thiram	3-4	
Tersan 1991	1-3	
Cleary 3336	1-3	
Fungo	1-3	
Sport Kleen	3/4-2½	

SUMMARY

1. Causal Agent: Fungus
2. Plant Parts Attacked: Leaf Tissue
3. Major Symptoms: Circular Brown Patches Bordered by Dark "Smoke Rings"
4. Time of First Noticable Symptoms: Mid-to-late summer following hot, humid weather conditions with prolonged minimum night temperatures above 65°F
5. Spray Program: Preventive Fungicide Sprays
6. Number of Applications Per Season: 4-6

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed on the label to be in compliance with the law. Avoid inhaling dusts or sprays. Open windows and ventilate the rooms while using pesticides. Never smoke or eat while spraying or dusting. Remove or cover food, feed, water, kitchen utensils and fish and other pets. Do not allow children near you when applying pesticides. Wash and clean up after using pesticides - change clothes if any pesticide was spilled. Dispose of empty containers safely. Bury 18" deep in an isolated area away from any water supply or place in a trash container. Do not burn aerosol cans. Store pesticides in their original containers in a locked cabinet or shed away from food. Be sure tops or caps are on tight. In case of an accident, follow label directions and call a physician immediately.

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University of New Hampshire

Pest Fact Sheet

No. 45

PESTICIDE APPLICATOR TRAINING

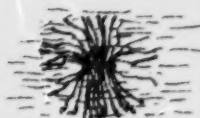
ORNAMENTALS



DUTCH ELM DISEASE



disease symptoms



tunneling



adult
beetle

INTRODUCTION

Dutch elm disease is caused by a fungus that is carried from tree to tree by elm bark beetles. The disease was first described in Holland in 1921 (where the name originated) and was first found in eastern U.S. in the early 1930's. It is the most destructive shade tree disease in the United States today. All elm species are affected, but the American elm is most severely affected.

DESCRIPTIONS

Disease Symptoms: The first symptoms to appear are the wilting or "flagging" of the leaves. These will then dry out, turn yellow (then brown) and drop off the tree. Defoliated twigs will usually die immediately. Dead branches may appear on a portion of the tree. The tree may then die, branch by branch, over a period of several years. The process is more rapid on succulent, fast-growing trees than on slowly growing or senile ones. Sometimes an entire tree will develop disease symptoms and die within a few weeks. This does happen when trees are planted so close to one another that the fungus from an infected tree enters an adjacent healthy tree through root grafts.

A branch or twig which is infected will, in x-section, show discoloration and an accumulation of brown gummy materials in the outer growth ring. If the bark is peeled back from an infected tree, tunneling of the elm bark beetle can be seen (see diagram above). These galleries are where the adult female beetle deposits eggs. The symptoms of Dutch elm disease are sometimes confused with those of drought injury or feeding by the elm leaf beetle; however, in these cases, there is no discoloration in the sapwood and no tunneling.

Description of the Elm Bark Beetle: There are two species of bark beetles that carry the Dutch elm disease fungus, the European elm bark beetle (*Scolytus multistriatus*) and the native elm bark beetle (*Hylurgopinus rufipes*). They are stout, reddish-brown

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beetles, about 1/8" long. They feed on the twigs, often in the crotches, of healthy elm branches, especially in or very near trees that contain weak, injured, or sickly portions.

LIFE CYCLE

The beetles overwinter as larvae at the end of their tunnels, pupate in the outer bark and begin to appear in May. They can be found continuously from May to September. Egg-laying extends over a considerable time, and there is a second (and possibly third) summer generation each year. Elm bark beetles will only lay eggs in dead or dying elm tissue.

The fungus overwinters in the bark of an infected tree, so the beetles may pick up the fungus spores as they tunnel in an infected tree. The fungus spores are spread to healthy trees when the adult beetle emerges and flies to another tree to complete its life cycle. In this way, both the disease cycle and the vector are closely connected. Throughout the summer months, the fungus grows and spreads causing the symptoms described above. A pile of dead elm logs favors the growth and spread of the disease, and the spread of the disease is especially favorable under humid conditions. The fungus can also be spread from tree to tree via natural root grafts.

CONTROL

- Cultural Practices:
1. destroy dead elm material (logs, dead trees, etc.)
 2. prune infected branches as soon as first symptoms are observed

- Chemical Practices:
1. control of disease vector (elm bark beetles) by bark and twig applications of methoxychlor to break the host-vector-pathogen link -- this should be done early in the spring before the buds break
 2. control of fungus by use of systemic fungicide such as benomyl or treat soil with vapam if there is danger of root grafting.

SUMMARY

- | | |
|------------------------------------|---|
| 1. Causal Agent: | Fungus |
| 2. Disease Vector: | Elm Bark Beetles |
| 3. Damaging Stage of Vector: | Adult |
| 4. Overwintering Stage of Vector: | Larva |
| 5. Number of Generations Per Year: | 2-3 |
| 6. Time of Year When Damage Done: | May - September |
| 7. Major Symptoms: | Flagging, Wilting, Browning of Current Year's Growth Ring |

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed on the label to be in compliance with the law.

COOPERATIVE EXTENSION SERVICE

University of New Hampshire

Pest Fact Sheet

No. 46

PESTICIDE APPLICATOR TRAINING

ORNAMENTALS



THE MAPLE TRUMPET AND THE OAK LEAF SKELETONIZERS

The Maple Trumpet Skeletonizer: The maple trumpet skeletonizer, *Epinotia aceriella*, ranges in distribution from Canada to North Carolina. In New Hampshire, it is found primarily on red and sugar maple but also occurs on hawthorn and beech. Damage from the larvae is usually not serious.

Adults are white moths with dustings of gray and brown. Larvae are light green in color with a yellowish head and are approximately $\frac{1}{2}$ " in length when full grown.

The larvae can be found feeding singly in late summer. They spin long trumpet-like tubes of silk on the underside of the leaves and feed within this tube, eating all of the leaf except the veins and upper surface. These tubes are speckled with frass.

Damage from this insect pest is done so late in the season that the cost of control is often unnecessary. However, when control measures are needed, carbaryl, methoxychlor, or diazinon can be used in late July to early August.

The Oak Leaf Skeletonizer: Oaks, especially red and black oak, are the primary hosts of this skeletonizer, *Bucculatrix ainsliella*. The larval stage causes the damage, feeding upon the leaves and causing them to become brown on the underside with the tops of the feeding area speckled and white.

The adult moth has a black forewing with pale areas outlining an oval, black patch on the inner margin. The full-grown larva is a yellowish-green color, approximately $\frac{3}{8}$ " in length. Several of these larvae can be found hanging by fine threads in the vicinity of oak trees in late June. The white ribbed cocoon is one of the most conspicuous signs of the oak leaf skeletonizer.

This skeletonizer spends the winter as a pupa within a cocoon on fallen leaves, on grass, on tree trunks, and on sides of buildings. There are two generations per year. The first generation is usually unnoticed due to the low population levels. Adults emerge in late May and the second generation begins in late July. Larvae feed in late May and June and again in late August through October.

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Carbaryl, methoxychlor, or diazinon applied in early June for the first generation and again in early August will give adequate control.

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed on the label to be in compliance with the law. Avoid inhaling dusts or sprays. Open windows and ventilate the rooms while using pesticides. Never smoke or eat while spraying or dusting. Remove or cover food, feed, water, kitchen utensils and fish and other pets. Do not allow children near you when applying pesticides. Wash and clean up after using pesticides - change clothes if any pesticide was spilled. Dispose of empty containers safely. Bury 18" deep in an isolated area away from any water supply or place in a trash container. Do not burn aerosol cans. Store pesticides in their original containers in a locked cabinet or shed away from food. Be sure tops or caps are on tight. In case of an accident, follow label directions and call a physician immediately.

James S. Bowman
Jon P. Turmel

Extension Entomologists

3/76/5C-es

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University of New Hampshire

Pest Fact Sheet

No. 47

PESTICIDE APPLICATOR TRAINING

ORNAMENTALS



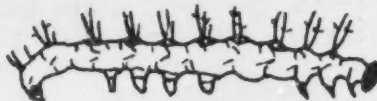
LEAF FEEDING
CATERpillARS

INTRODUCTION

The term "caterpillar" is generally used to describe the larvae of moths and butterflies. They come in a variety of sizes, shapes, and colors, with and without hairs or spines. They differ from sawfly larvae in that they have 5 or less pairs of prolegs on the abdomen which bear crochets (hooks) and the head capsule usually has 6 eyes on each side.

Caterpillars devour the foliage of trees and shrubs, either causing complete defoliation or leaving holes and irregular areas. There are several species that are important pests in New Hampshire.

Spiny Elm Caterpillar (*Nymphalis antiopa*)



The adult of this caterpillar is commonly known as the morning-cloak butterfly. Full grown caterpillars are black, with white and red dots scattered along the top of the abdomen. The head is covered with tubercles and the body has many large, branched spines. They commonly feed on elm, willow, poplar, and hackberry. The overwintering butterfly lays eggs in the spring and the larvae of the first generation are found in June and early July. A second generation occurs in late summer. The young larvae feed in groups until almost full grown.

Red-humped Oak Worm (*Symmerista canicosta*)



This species occurs throughout the northeast where it prefers oaks and other deciduous trees such as basswood, sugar maple, paper birch, beech, and elm. The adult is an ash gray moth while the full grown larva has a rounded, orange-red head and a yellowish body that has an orange-red enlargement (hump) on the 11th segment back from the head. The body is also marked with fine black lines on the top and has mottled areas on the sides.

Moths appear from May - July and lay eggs on the underside of leaves. The young larvae feed in groups and skeletonize the leaves. Older larvae feed alone and eat all except the larger veins. Pupation takes place in the ground. There is

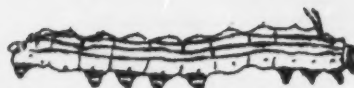
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one generation per year.

Green Striped Mapleworm (*Anisota rubicunda*)



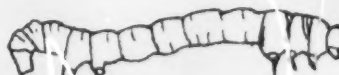
The preferred hosts of this worm are maples but it will also feed on oak and box elder. It occurs throughout most of the eastern U.S. and the population may become heavy enough to cause serious defoliation. The moth is yellow on top and pinkish beneath with a woolly body. The full grown larva has a cherry-red head, pale yellow-green body and are about 37 mm long. It has seven dark green to black lines running its length, two slender horns on the thorax and two rows of short spines on each side of the body.

Eggs are laid on the leaves in May and June. The larva feed singly and devour the entire leaf. They become full grown in one month. There is one generation per year in New Hampshire.

Cankerworms (Spring and Fall)



spring



fall

The spring cankerworm (*Paleacrita vernata*) and the fall cankerworm (*Alsophila pometerga*) are common to the northeast and attack a variety of deciduous trees; but prefer elm and apple. The larvae of the two species occur at the same time of the year and cause the same type of damage. The primary difference between the two species is that the adult moths of the spring cankerworm emerge in April and May to lay eggs, while the fall cankerworm moths emerge in November and December to lay their overwintering eggs.

The larvae of the two species are known as inchworms, measuring worms, or loopers. They vary in color from green to brown but can be distinguished in that the fall cankerworm has 3 pair of abdominal legs while spring cankerworms have 2 pair. The female moth in both species is wingless.

The larvae feed on the foliage and buds early in the season and can completely defoliate a tree. Two or three years of defoliation can kill a tree.

CONTROL

Most leaf feeding caterpillars are easily controlled by spraying with carbaryl, methoxychlor, or malathion when the larvae first become active.

Applications for cankerworms should be made in May when the leaves are developing. Treatment should be made in June and July for the spiny elm caterpillar, red-humped oak worm and green striped maple worm.

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed on the label to be in compliance with the law. Open windows and ventilate the rooms while using pesticides. Avoid inhaling dusts or sprays. Never smoke or eat while spraying or dusting. Do not allow children near you when applying pesticides. Wash and clean up after using pesticides - change clothes if any pesticide was spilled. Dispose of empty containers safely. Bury 18" deep in an isolated area away from any water supply or place in a trash container. Do not burn aerosol cans. Store pesticides in their original containers in a locked cabinet or shed away from food. Be sure tops or caps are on tight. In case of an accident, follow label directions and call a physician immediately.

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University of New Hampshire

Pest Fact Sheet

No. 48

PESTICIDE APPLICATOR TRAINING

ORNAMENTALS



LEAF FEEDING BEETLES



INTRODUCTION

Along with certain caterpillars and sawfly larvae, there are certain species of beetles that are important pests on ornamental trees and shrubs because they destroy foliage. Most chew holes in the leaves giving them a skeletonizing effect and causing the leaves to turn brown and drop off the tree. In some cases, both the adults and the larvae cause the damage. Some of the important leaf feeding beetles in New Hampshire are described below.

Elm Leaf Beetle (*Pyrrhalta luteola* Muller)



This pest can build up in large numbers and cause considerable destruction to all species of elms. The adult beetles, which are about 6 mm long and yellowish to dull green with a black stripe along the sides of the wing covers, spend the winter in protected areas, such as in attics and barns. They emerge in the spring and lay egg masses on the underside of elm leaves.

The larvae hatch in about 1 week and feed on the underside of the leaves for 2-3 weeks causing a typical skeletonizing damage. Young larvae are black when newly hatched but become dull yellow with black stripes down their back when full grown. When mature, they crawl down the trunks and pupate around the tree or in crevices in the trunk. Some of the emerging beetles will repeat the life cycle while most will seek hibernating quarters. Often, adult beetles hibernate in houses where they emerge into warm living quarters and become uninvited guests.

Elm leaf beetles do not transmit the Dutch elm disease fungus but the weakening of the trees through leaf loss will make them attractive to the bark beetle carriers of the disease.

Imported Willow Leaf Beetle (*Plagioderma versicolora* Laich)



This introduced species attacks several varieties of willow and poplar. The

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adult beetle is metallic blue or greenish in color, oval, and 3-4 mm long. It spends the winter under bark or in grass and debris near the base of the tree. They emerge in April or May and begin feeding on willow leaves causing a skeletonizing effect. Eggs are laid in irregular egg masses which hatch in about a week. The young larvae feed in groups or in rows on a leaf surface. The fully grown larvae are black, about 5 mm long, and have rows of protuberances the length and across the body. There are 3-4 generations per year.



Rose Chafer (*Macrodactylus subspinosus* Fab.)

The adult beetle of this species is tan to reddish brown, densely covered with dull yellow hairs, and have long, reddish-brown legs. They feed on a large number of trees and shrubs including grape, apple, peach, cherry, flowering crab, hawthorn, roses, and others. The winter is passed as a grub in the soil similar to white grubs or Japanese beetle grubs. The adults emerge in May or early June and feed on the buds and developing leaves of many host plants. Sometimes when the infestation is heavy they appear in swarms. They feed on the surface of the leaves and produce the skeletonization effect. Eggs are laid in the soil and the larvae feed on the roots of grasses but cause little damage.



Japanese Beetle (*Popillia japonica* Newman)

The Japanese beetle adult causes similar feeding damage on a variety of ornamental trees, shrubs, and food crops. For more information on its habit and life history, see Pest Fact sheets No. 23 and 39.

CONTROL

Applications of either carbaryl or methoxychlor when the adults or larvae are actively feeding on leaves are recommended for control of these pests. To prevent defoliation, treatments should be made as soon as the beetles appear. Repeat applications as needed in accordance with the label.

SAFE USE OF PESTICIDES

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